NATURE STUDY AND SCIENCE

TRAFTON

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NATURE STUDY
AND
SCIENCE

BY

GILBERT H. TRAFTON

INSTRUCTOR IN SCIENCE, STATE TEACHERS COLLEGE,
MANKATO, MINN.

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PREFACE

THE increasing importance of science in modern life is naturally compelling the study of more science in our schools. For a number of years considerable attention has been paid to science in the high schools. In recent years general science has found its way quite universally into the junior high school, where it is taught chiefly in the last year, the ninth grade. There are indications here and there that eventually it will be spread out over the seventh and eighth grades also and made into a three-year course.

The next logical step will be the introduction of more science into the intermediate grades, which feel above them the stimulation of the general science work being done in the junior high school and below them the urge of the nature-study work being done in the primary grades. The intermediate grades must bridge the gap between these two extremes by working out a course that will contain elements from both movements, harmonize them, and advance the child from the simple nature-study interest to the interest in useful and applied scientific knowledge.

In past years the tendency in the intermediate grades has been to emphasize too much the study of the plants and animals and to neglect the physical sciences. A properly balanced course must take into account both kinds of science. The general purpose of science in these grades may be said to be two-fold: first, to familiarize the child with the common plants and animals in his environment, to interest him in their structure, life histories, and beauty, and to develop some appreciation of their economic importance in man's life. The second purpose should be to study some of the applications of physical science in the play life of the child and in modern life and to learn some of the simpler laws and principles underlying these applications, in so far as they may come within the comprehension of the children in these grades. Such in brief are the aims of this text.

The author takes pleasure in acknowledging his indebtedness for many helpful suggestions to the following teachers connected with the Training School of the Mankato State Teachers College: Mr. Otto W. Snarr, Director; Mrs. Minnie E. Parry, Head Training Teacher, Intermediate Grades; and Miss Lina E. Miller, Training Teacher, Intermediate Grades. He also acknowledges gratefully permission received from Houghton Mifflin Co. to use the few selections taken from his *Teaching Science in the Elementary Schools* which they publish.

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TO THE TEACHER

This book is to be used as a text in the hands of children in the intermediate or the grammar grades. It will aid teachers in at least two ways: first, by relieving them of much labor in the detailed outlining of plans for the study of nature and science; and second, by helping them to instill in children independence and a sense of responsibility in carrying on their work. The book is intended to serve pupils both as an inspiration in the development of scientific interests and as a handbook by which they may pursue those interests intelligently.

The text contains two types of material: first, reading matter designed to give the child information and to arouse interest in the work; and second, projects in which the pupils' own work in observing and doing is directed to a definite end. The first kind of material has been printed with much more space between lines, while the lines of the latter are set more compactly.

These projects may be carried on in a variety of situations: in the schoolroom, on field trips, on the playground, in connection with the children's sports, and at home. They have been divided into two classes: *group projects* and *individual projects*. In the group projects all the members of the class work together at one time. In the individual projects each child works independently by himself, either in or outside of the school. The child should be allowed to take his book home and work some of the projects there.

Most of the experiments are examples of group projects. One set of apparatus will be enough for the whole class. The experiments may be performed before the class by the teacher or, better, by a group of children selected for the purpose. It will be well to have these groups perform their experiments first by themselves, so that they may be more confident in performing them before others. (*G*) after a project number indicates a group project, and (*I*) indicates an individual project.

Both teacher and pupils will find the Table of Projects in the Appendix, pages 343–354, a helpful means of keeping a record of progress. Pupils may be permitted to check neatly and simply on this list those projects that they have carried out, either in groups or individually.

On pages xv to xxii is given a table suggesting how the various topics may be divided among the three grades. This plan, of course, is merely suggestive and leaves the teacher free to adapt locally and to make such other assignments as may be preferred. In rural schools the children of three selected grades may be grouped in one class, and selected portions of the book may be used each year. In order to avoid repetition from year to year, the work may be divided into two groups and alternated from year to year. Such a division is suggested in the table on pages 355–359.

The teacher's attention is called especially to the suggestion given in the introduction, To the Boys and Girls, that individual science notebooks be kept. Since frequent use is made of these notebooks, special attention should be given at the outset to provide proper material for them.

As a means of furthering the interest that these lessons may arouse, the children should be encouraged to do supplementary reading. For this purpose a list of books adapted to children of the intermediate and grammar grades is given in the Appendix.

For further discussion of the principles involved in teaching science, the teacher is referred to the author's The Teaching of Science in the Elementary School.

SUGGESTED DIVISION OF WORK FOR THREE-YEAR COURSE

PART ONE — AUTUMN STUDIES

	COURSE I		COURSE II		COURSE III	
	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)
CHAPTER 1						
GARDEN STUDIES						
Garden Flowers . . .	3	1	3	2, 3		4, 5
Vines					7–10	6, 7, 8, 11
Bulbs	11–13	9	13–16	10		
House Plants from Cuttings					17–19	12
CHAPTER 2						
WILD PLANTS						
Wild Flowers		13		14, 15		16
Mushrooms			22–25	17, 18		
Ferns					26	19
Weeds		22		20, 21	27–30	23, 24
Trees		28, 29, 30	32–37	25, 32, 33	32–37	26, 27, 31
Seed Travelers . . .	42–45	34				

	COURSE I		COURSE II		COURSE III	
	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)
CHAPTER 3						
SOME INTERESTING INSECTS						
Insect Activities . . .	46–48 51, 52,	36, 37, 38, 39	53–54	35, 40	56 ; 58	41, 42
Galls	59	43				
Social Insects			61–65	44	66–68	45
Garden Insects . . .					69–71	46
Household Insects . .					72–74	47
CHAPTER 4						
OTHER INTERESTING CREATURES						
Spider Webs	76–78	48				
The Earthworm . . .					79	49
Bird Nests			80–81	50, 51, 52		
CHAPTER 5						
THE SCHOOL AQUARIUM						
Fishes	84–89	53				

	Course I		Course II		Course III	
	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)
Tadpoles			90	54		
Water Insects . . .					91–95	55
Chapter 6 Rocks and Minerals						
Rocks	97	56	98–100	57		
Minerals					102–104	58, 59
Chapter 7 Playground Sports						
The Seesaw			105–106	60		
The Swing					109–110	61, 62, 63
Chapter 8 Stars and Constellations	112–115	64		65		

PART TWO — WINTER STUDIES

	Course I		Course II		Course III	
	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)
Chapter 9						
Winter Birds	125–127	66	125–127	67	127–130	68, 69
Chapter 10						
Trees in Winter						
Evergreens	134	70				
Deciduous Trees . . .			136–139	71	140–142	72, 73
Chapter 11						
Outdoor Winter Sports						
Coasting	144–148	74, 75				
Skating		76	149–151	77	152–153	78, 79, 80
Chapter 12						
Indoor Winter Amusements						
Toys						

	COURSE I		COURSE II		COURSE III	
	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)
Magnets	158	81				
The Motor	160–161	82				
The Compass	162	83				
The Kaleidoscope			163–4	84, 85		
The Color Top			166	86		
The Camera			167–169	87, 88		
The Airplane					171–172	89,90
The Gyroscope					174–178	91, 92
Tilly Tinker, the Balancing Queen					180–181	93, 94
Experiments to Entertain Friends						
Surface Tension of Water	184	95				
Chemical Experiments			184	96, 97		
Frictional Electricity			186–188	98		
The Weight of the Air			189–190	99		
The Magic Penny					194–195	100
Experiments with Ice					196–197	101, 102
Capillarity					199–200	103

	COURSE I		COURSE II		COURSE III	
	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)
Experiments with the Eye		104, 105, 106				
Moving Pictures					201–209	107
CHAPTER 13						
SKY STUDIES						
The Sun	210–211	108				
The Moon			212–217	109		
The Stars					217–219	110
The Planets					223–225	111
CHAPTER 14						
PETS						
The Dog	227–230	112				
The Cat	231–234	113				
The Canary	234–235	114, 115				

PART THREE — SPRING STUDIES

	Course I		Course II		Course III	
	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)
Chapter 15						
The Weather	242–244	116	239–242	117	245–249	118, 119 120
Chapter 16						
Toys for Windy Days						
Kites	254–255	121				
Windmills			257	122, 123		
Chapter 17						
Gardening		124, 126, 127	260–265	125, 128, 129, 131	260–265	130, 132 133, 134 135, 136
Chapter 18						
Birds						
The Home Life of Birds	275–279	137				
Songs of Birds					280–282	138
The Travels of Birds . .			282–285	139		

	COURSE I		COURSE II		COURSE III	
	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)	Reading material (pages)	Projects (number)
The Practical Value of Birds					288–290	
Bird Houses	290–292	140	290–292	141		142
Fountains		143				
Projects in Bird Study .		144, 145		146, 148		147, 149
Bird Clubs and Other Activities		152		150		151
CHAPTER 19						
Flowers	305	154, 155		153, 156, 157	306–310	158, 159
CHAPTER 20						
Trees	319	160, 165	321–322	161, 164	316–318	162, 163
CHAPTER 21						
WATER SPORTS						
Swimming					324–333	166
Boating		169	333–335; 338	168	336–337	167
Water Wheels		170				

TO THE BOYS AND GIRLS

This book was written to help you learn about the great world of nature and science that lies everywhere about you. You can learn about this world of nature in two ways:

(1) by reading about it,
(2) by observing and working with nature yourselves.

This book aims, therefore, to help you in both of these ways; (1) it tells you some of the things that would be too hard for you to find out by yourselves, and (2) it shows you how to discover other things. The more you learn about nature, the more you will be able to observe.

That reading material which is to give you information appears with much wider spacing between the lines; while the parts that direct you in observing and experimenting are set much more compactly.

The book contains many plans that direct you how to observe and to discover things of interest. These plans are called *projects*. There are 170 of them in all, or an average of about 57 for each of the three years. How many of them do you think you can carry out in one year? Of course you will not forget that a good quality of work — that is, work that is complete and careful — is better than a great quantity. Some of the projects may be worked out by the class as a whole or by a *group* chosen from the class; they are, therefore, marked (*G*). Others may be worked by each one of you *individually*, sometimes in the schoolroom and sometimes outside; they are marked (*I*).

You may take turns in preparing group experiments that are to be performed before the class. When your turn comes to do the experiment, secure the needed material in advance and work out the experiment by yourselves under the teacher's direction so that you will know just how to do it well before the class.

Besides the many projects that are described in the chapters of this book, there are two big plans that should be carried out in all your work with nature and science. They are the keeping of your own science notebook and the making of a school museum.

Making a Science Notebook

It is much easier to make a science notebook than it sounds. All that is needed is a simple book in which you can write the results of your observations and your experiments. Here, too, you may place clippings and illustrations that you cut from magazines or newspapers. Some of your illustrations you will produce yourselves. Some of these may be drawings made with pencil, while others may be colored by using either crayons or water colors. All such pictures should help to tell the nature story or the science story in which you are interested. At the end of the year you will find such a science notebook, the work of your own brains and hands, worth keeping and showing to others. When you look it through, you will realize just how completely it is yours. Everything in it will be your work. Before you begin, it will be well to consult with your teacher as to the best kind of notebook to get for your purposes. Perhaps you can design something for the cover that is attractive, similar to the suggestions shown in figure 1, page 4.

The School Museum

The school museum, of course, is properly group work. You and your classmates, working together, can make the collections for a simple school museum. These collections are of value to you in bringing them together, and to others who see and use them in the future. This book contains many suggestions as to what to collect.

Of course, you will need to provide a place where your collections may be kept. Those of you who are interested and skilled in manual training can doubtless make a simple case or put up some shelves in a convenient place. The different objects of the collection can be properly labeled by using cards of uniform size. Labels should describe the object in as few words as possible and give the name of the person who made the contribution as follows:

Robin's nest,
donated by Clara Goodwin.

Sometimes it is desirable to know where the object came from because the place in which it is found may tell us something about its life history. An answer to the question "where found?" may, therefore, often profitably be added to the card.

PART ONE

AUTUMN STUDIES

CHAPTER I

GARDEN STUDIES

A. Garden Flowers

Autumn is a good time to study many garden flowers so as to learn their names and find out which ones you would like to plant next spring. The garden flowers we have to plant anew each year are called *annuals.* Their life time, starting with the sprouting seed and ending with the ripening of new seed, lies within one year.

Garden flowers may be divided into two groups, hardy and tender, according to the time at which the seeds should be planted in the spring. The seedlings of the hardy flowers are not killed by the late spring frosts; so these seeds may be planted early in the spring. The seedlings of the tender annuals are killed by the late spring frosts; so their seeds cannot be planted till the late spring. The exact time for planting these seeds varies with the climate and locality. For the region of New York City the hardy annuals may be planted about the middle of April, and the tender annuals about the middle of May. In the Southern States or in California they may be planted earlier.

Project 1 (I). Determining how hardy annual flowers are affected by the early autumn frosts.

1. Copy this list of a few hardy annuals in your science notebook in one column on the left:

California poppy
candytuft
nasturtium
phlox
sweet alyssum
sweet pea
verbena
zinnia

2. How many of these flowers can you find growing in gardens? After the name of each in your book write the color of the flower. **3.** After the first autumn frosts notice whether these flowers have been killed. Keep watch from week to week; and as soon as you find any flower killed by a frost, put the date of the frost after

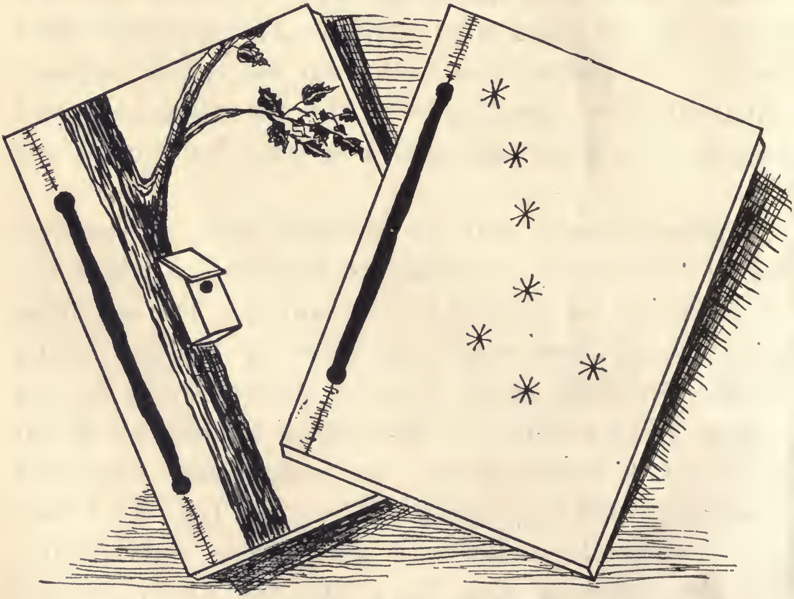


Fig. 1. Suggestions for notebook cover.

the name of the flower in your book. **4.** Which of these flowers would you like to plant in your garden next spring? Why do you prefer these?

Project 2 (I). Determining how tender annuals are affected by the early autumn frosts.

1. Copy this list of a few tender annuals in your science notebook in one column on the left:

aster
balsam
cosmos
four-o'clock
marigold
portulaca
petunia
velvet flower

2. How many of these flowers can you find growing in the gardens? After the name of each in your book write the color of the flower. **3.** After the first autumn frosts notice whether they have been killed. As soon as you find any flower killed by frost, put the date of the frost after the name of the flower in your book. **4.** Which ones would you choose to plant in your own garden? Why do you prefer these? **5.** Write in your book the names of any other flowers you find besides those in the list.

Project 3 (G). Finding the easiest way of telling the phlox and the zinnia apart. (Any two flowers may be chosen.)

1. Compare the whole plants. Which is the taller? Which has the bigger leaves? Do the leaves differ in any other way — such as shape, arrangement, etc.? **2.** How do the flowers differ in color? Does either flower have more than one color? Which plant has the bigger flower? Is there any difference in the odor of the flowers? **3.** Which flower do you like better? Why? **4.** Make some drawings of these flowers in your science notebook, using either colored crayons or water colors.

Project 4 (I). Learning the names and appearances of the perennial flowers that bloom in the autumn.

1. The tops of most flower plants die in the late autumn, but the roots of some plants live through the winter and send up new stems in the spring. Those flowers whose tops and roots both die in the autumn are called *annuals*, and those whose roots live through the winter are called *perennials*. **2.** Ask your friends to let you see the perennials growing in their gardens. Also look at those in the flower gardens in the parks. **3.** Make a list of these flowers in your science notebook. After each name write the color of the flower. **4.** Which of these flowers would you prefer to have growing in your garden? Why?

Project 5 (G). Reviewing the names of the autumn garden flowers.

1. In the later autumn when the flowers are all gone review the names of all the garden flowers you know. **2.** Secure a large piece of heavy paper about two feet square and draw vertical lines on it several inches apart, dividing the space into five columns. At the top of each column put the name of a color as follows:

Schedule of Garden Flowers

Red	Yellow	White	Blue	Variegated

3. Recall the names of all the garden flowers you can and have the teacher write them in the appropriate columns according to the colors of the flower. **4.** Or if you prefer, you can start this calendar early in the autumn and fill in the names of the flowers as you see them growing. **5.** After the above table is finished, copy it in your science notebook.

B. Vines

Why should vines be planted? Vines add greatly to the attractiveness of the home yard. They may be planted against buildings to add to their beauty (Fig. 2); they may be used to shut out some objectionable view; or they may be grown over arbors to furnish shade during the hot summer days.

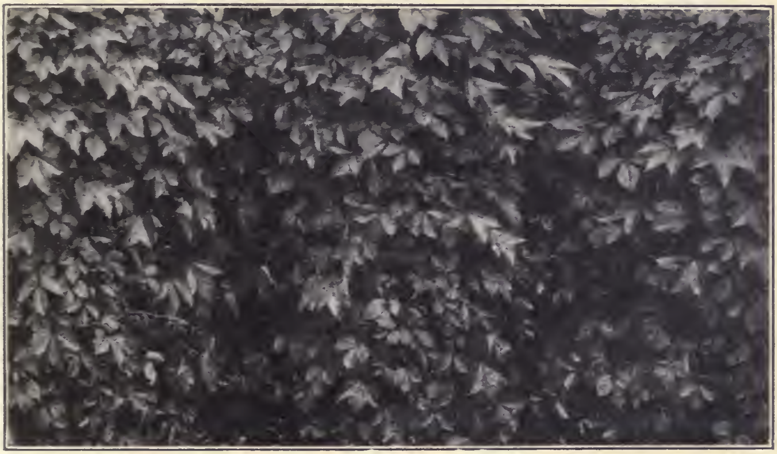


Photo from J. Horace McFarland Co. Harrisburg, Pa.

Fig. 2. A "Leaf mosaic."

How long do vines live? Vines, like the garden flowers, may be divided into two groups: *annuals* and *perennials*. The annual vines live only one season. When the cold weather comes, the whole vine, both stem and root, dies. However, the seeds may be saved and planted the next spring, and thus we may have the vine year after year. The perennial vine lives several, sometimes many, years. In some cases only the root lives during the winter; in other cases both root and stem live. Since the stem begins growing in the spring where it stopped in the autumn, these vines may grow to a great length in a few years.

How do vines hold on? Vines have two characteristics that are very different from other common plants. First, the stems are very long in comparison with their thickness; and second, the vines, because their great length makes them too heavy for their slight stems, are not able to hold themselves erect but must climb on some support. One of the most interesting things to study about vines is the methods by which they climb and hold on to the supports on which they are found. Different vines hold on in different ways. Some climb by twining or circling the stem around and around the support and are called twiners. Others send out long leafless tendrils that twine around some object and thus tie the vine to its support. Still others are provided with suckers which cling very firmly to flat surfaces. These many little sucker hands thus hold the vine up. Finally, instead of special tendrils to wind about objects the leaf stems of some vines will curl about slender objects that give support. Explain Fig. 3.

Now you have an interesting investigation that will occur to you whenever you meet a vine. Hunt up some grape vines, climbing nasturtiums, morningglories, woodbine, ivy, and the like, and see if you can tell whether they are stem twiners, leaf twiners, or vines that hold on by special tendrils or suckers. If you can do so without injuring anything, experiment with the strength with which they hold on. Give special attention to the grape vine, for it has a way of even beating the wind.

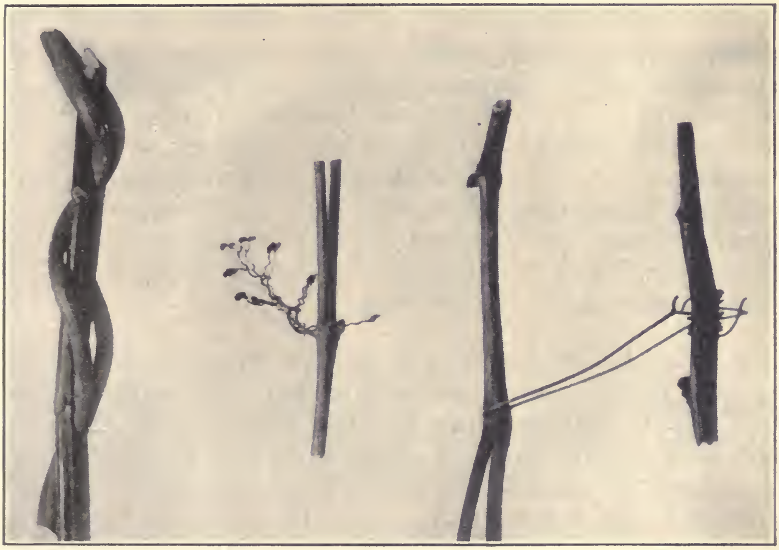


Fig. 3. How vines hold on.

When one is planting vines around the home, he needs to know how the vines climb, in order to provide the proper kind of support. The woodbine needs no special support, for it can attach itself by means of its suckers to the stones or bricks of the building. For twiners and for those vines that climb by means of tendrils, some support, such as wire, a pole, or a string, must be provided.

Project 6 (I). Learning the names and appearances of many different kinds of vines.

1. Copy this list of a few common vines in your science notebook in one column on the left.

balloon vine
bittersweet
Boston ivy
canary bird flower
clematis
climbing buckwheat
cypress vine
Engelmann's ivy
everlasting pea
gourd
honeysuckle
hyacinth bean
Japanese hop
moonflower
moonseed
morning-glory
smilax
sweet pea
trumpet creeper
wild clematis
wild cucumber
wild grape
wild morning-glory
wild peanut
wisteria
woodbine

2. This list includes both cultivated and wild vines. Look in gardens and by roadsides and visit parks to see how many of these vines you can find. **3.** As soon as you find a vine, check it off in your list and put after the name the method by which the vine climbs. **4.** If you find any vines not in your list, add the name to those you already have. **5.** In the autumn notice how the leaves change in color. Which vines have the prettiest colors?

Project 7 (G). Making a collection of vines for the school museum.

1. Collect as many vines as you can, both wild and cultivated. For each vine collect a leaf and enough of the plant to show how it holds on. **2.** Put these between the pages of an old book or a magazine and place some weight on top. Allow them to press for a week or two. **3.** Get a large piece of heavy paper about two feet long and one foot wide and write across the top: *How Vines Climb.* **4.** Fasten the pressed specimens on this paper by means of glue or, better, by strips of gummed paper. **5.** Under each vine write its name and the method by which it holds on.

Project 8 (G). Arranging vines according to their method of holding on.

1. Draw vertical lines on the blackboard, dividing the space into four columns, and write the following headings at the top.

How Vines Hold On

Stem twiners	Leaf twiners	Tendrils	Suckers

2. Recall the names of all the vines you can and have them written in their proper columns. **3.** Copy the completed table in your science notebook.

C. Bulbs

Outdoor Bulbs

After fall bulbs are once planted, they need no further care until the next spring, when a little weeding may be necessary. They are much larger than seeds and are therefore easier to handle and to plant. Another reason for planting bulbs is that they bloom in the early spring, at a time when few other flowers are in blossom.

When should bulbs be planted? Although their roots grow during the cold weather, they cannot grow when the ground is frozen. For this reason the bulbs should be planted early enough to let the roots form before the soil freezes — sometime between the first of October and the middle of November. The farther north one lives, the earlier the bulbs should be set out.

How should bulbs be planted? The soil should be enriched with manure and thoroughly spaded to a depth of a foot or more. The larger the bulb, the deeper it should be planted; this depth varies from two to six inches. (Fig. 4)

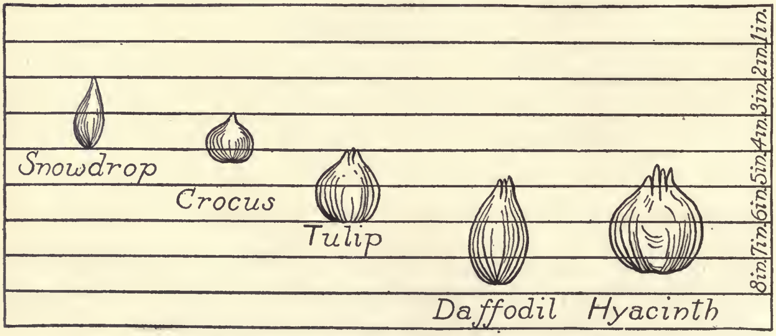


Fig. 4. Depths for planting bulbs outdoors.

A good location for the bulb bed is around the border of the lawn, along a fence or sidewalk, or in front of the porch. A variety of bulbs should be chosen so as to produce flowers during a number of months. The following table gives the information. The dates of blooming are for the latitude of New York City; farther north they are later, and farther south, earlier.

TABLE OF BULBS FOR OUTDOOR PLANTING

Name	Depth (inches)[1]	Distance apart (inches)	Month in bloom	Length of bloom (weeks)	Colors	Height (inches)
snowdrop	2	2	March	3	white	3–4
crocus	3	3	March	2	blue white yellow	6–8
hyacinth	5	6	April	3	red blue white yellow	8–18
tulip	4	5	April May	3	yellow white red	10–18
narcissus (daffodil)	5	5	April May	4	white yellow	12–18

[1] Measured from top of bulb.

Project 9 (I–G). Planting bulbs in the home yard or school grounds so as to get flowers in the spring.

1. Find out whether you can have a place in your home yard where you can plant bulbs. Perhaps there is a place in the borders of the school yard where you and your schoolmates can plant some in order to make the yard attractive next spring. **2.** After you have decided on the place in which to plant the bulbs follow the directions already given in this chapter regarding the time and method of planting.

Indoor Bulbs

In the foregoing section of this chapter directions were given for planting bulbs out of doors; in this section, directions will be given for planting bulbs indoors so as to have flowers in the house during the winter. The same kind of bulbs may be used in both cases, only in the latter case the bulbs are forced so that they bloom more quickly. Bulbs to be kept indoors are put in flower pots.

How should the bulbs be planted? Some bulbs are better adapted than others for raising indoors. The table on page 15 gives some of those which grow most satisfactorily. The number of bulbs to be planted in a pot depends on the size of the bulbs and the size of the pot. Three bulbs of the size of a Roman hyacinth bulb may be placed in a pot that is five inches across the top. There should be a hole in the bottom of the pot covered with some coarse material, such as large pebbles, to allow drainage. After the bulbs are planted, the soil should be thoroughly watered. They are not planted as deeply as outdoor bulbs; it is enough just barely to cover the tip.

Where should the flower pots be kept? In order to duplicate as far as possible the conditions that are found when bulbs are planted outdoors, the pot should be set in a place that is both *dark* and *cool*. The chief thing to consider is the temperature. The Chinese lily and the paper-white narcissus cannot stand freezing; but no harm is done if the other bulbs mentioned in the table on page 15 are allowed to freeze.

The same thing happens to bulbs planted in flower pots that happens to those planted in the ground; that is, the bulbs develop a large mass of roots. (Fig. 5) During this period the soil should be kept moist. If the soil is well watered at first and covered, this one watering will often be enough until the bulbs are brought into the room. Indoor bulbs may be started at any time from the first of October to the middle of the winter.

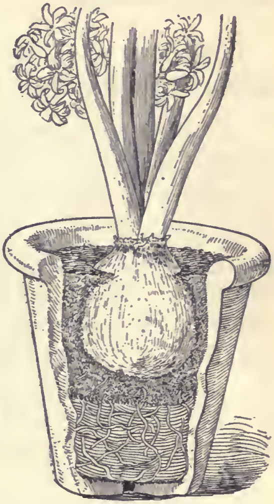


Fig. 5. Hyacinth bulb that formed roots while it was in the dark.

When should the flower pots be brought in? The length of time that the bulbs must be kept in this cool, dark place depends on the rapidity with which the root system forms. The time schedule given in the table indicates the shortest periods allowable; the bulbs may be kept out as much longer as one desires. After the proper time has passed, the bulbs may be brought into the ordinary living room. They should be watered and cared for like any house plant.

TABLE OF BULBS FOR INDOOR BLOOMING

Name	Time to keep in dark	Time to bloom after brought to light	Time remaining in bloom
Chinese lily	2 weeks	5–6 weeks	3 weeks
paper-white narcissus	5–6 weeks	5–6 weeks	3–4 weeks
daffodil	8–12 weeks	4–6 weeks	2–3 weeks
Dutch hyacinth . .	10–12 weeks	6–7 weeks	2 weeks

When bulbs are to be raised for use in the schoolroom, a satisfactory plan is to let the bulbs stay in the cool, dark place until after the Christmas vacation. Then there will be no trouble about the care of the plants during vacation.

Project 10 (G–I). **Planting bulbs indoors either at home or at school in order to have flowers indoors next winter.**

1. You can arrange now to plant bulbs so that next winter you will have flowers to make your schoolroom attractive. Probably some of you can bring flower pots from home. The bulbs do not cost much, and you can easily raise the necessary money if each gives a few pennies. **2.** Read carefully the preceding section of this chapter and follow the directions. This work may be started at any time during October or November. **3.** At the same time that you are planting bulbs in the schoolroom you can also be planting some at home to furnish winter decoration there.

Project 11 (I). **Raising flowers from Chinese lily bulbs to be given as a Christmas present to a friend.**

1. One unusual Christmas present can be made by starting a Chinese lily bulb early enough so that it will be in blossom at Christmas time. This should be started about eight weeks before Christmas; that is, during the latter half of October. **2.** Secure a shallow glass dish from six to ten inches across and fill it half full of clean pebbles or sand. Set the Chinese lily bulbs on the pebbles and pile the peb-

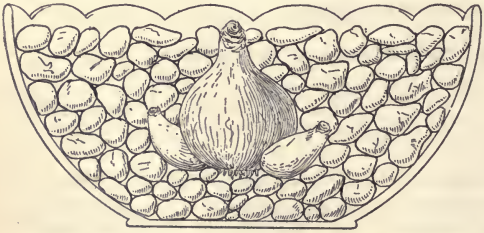


Fig. 6. Section of a dish showing method of planting bulb of Chinese lily.

bles around the bulbs so as to hold them up. (Fig. 6) In an eight-inch dish three bulbs may be placed. Pour water into the dish till it touches the bottom of the bulb. People often make the mistake of covering the entire bulb with water, which may cause the bulb to rot. **3.** Now place the dish in a dark closet that is fairly cool. Every few days add water enough to keep it in contact with the bulb. Soon roots will begin to grow from the bulb. In about two weeks bring in the dish and place it in a light, warm room. Keep it well watered. In a short time the leaves and flower stalks will begin to grow. **4.** By Christmas day the bulbs will be about ready to bloom, and the dish can then be given to your friend. (Fig. 7)

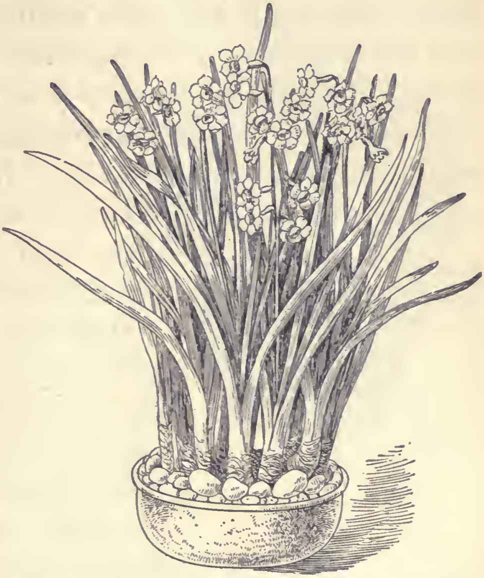


Fig. 7. Chinese lilies raised in pebbles and water.

D. House Plants from Cuttings

There are many different kinds of plants that may be used to decorate the home — bulbous plants, plants of the fern family, and plants of the palm family; but one of the most interesting kinds for us to work with is the house plant that is raised from a cutting.

Three ways in which house plants may be raised. You are familiar with the common way of raising garden plants from seeds and with raising plants from bulbs. Still another way of raising plants is from cuttings, a method that will be explained in the following pages. This method is better than raising plants from seeds, because you get quicker results. In raising plants from cuttings, you start with a piece of the stem of a large plant, and only wait for a new set of roots to grow.

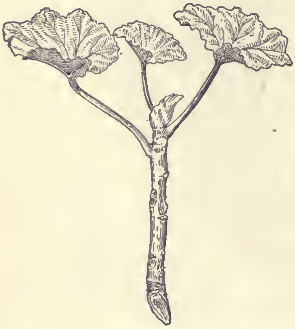


Fig. 8. A geranium cutting.

How are the cuttings cared for? A window box or flower pot is partly filled with clean sand. Cuttings of stems about three inches long are taken from growing plants, and all the leaves except three are trimmed off. (Fig. 8)· A hole is made in the sand, the stem of the cutting is inserted for about an inch, and the sand is then pressed firmly around it.

The sand should be watered often enough to keep it moist all the time. Water is passing out of the leaves and constantly evaporating. If too much passes out, the cutting will wither and die. Two things should be done to prevent this wilting: first, the sand should be kept moist; and, second, the window box may be covered with a pane of glass to lessen the amount of water that evaporates from the leaves. In raising only a few cuttings an ordinary flower pot may be used and the cuttings covered with an inverted tumbler. (Fig. 9)

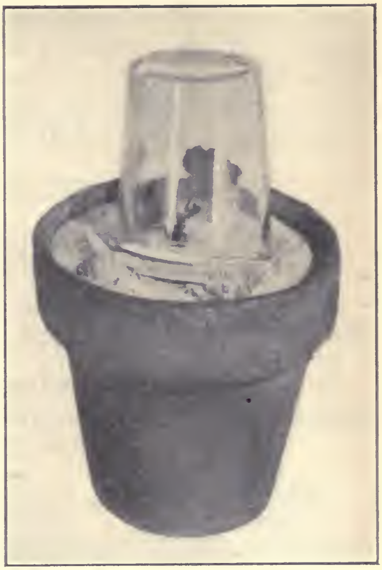


Fig. 9. Growing a cutting.

The cuttings must be kept in the sand until roots have formed. The growth of new leaves on the cutting is an indication that the roots have begun to develop. For a plant like the geranium, from five to six weeks are usually needed. The cutting should then be carefully taken out of the sand and put into another flower pot containing ordinary soil.

Project 12 (G). Raising plants from cuttings to furnish both the home and the school with house plants.

1. Some of the easiest plants to raise are the geranium and the Wandering Jew. Try other kinds also, such as begonia and fuchsia. When filling the box with sand, leave enough space so that a pane of glass may be placed over the box without touching the cuttings. **2.** You can all take turns looking after the plants and seeing that they are properly watered. When the cuttings have grown enough so that they may be transplanted, you may bring flower pots from home and take your plant back with you.

CHAPTER II

WILD PLANTS

A. WILD FLOWERS

Project 13 (I). Learning the names and characteristics of the common wild flowers one sees in the autumn.

1. Here is a list of a few common flowers found in the northern and eastern portions of the United States. Copy the list in your science notebook in one column on the left.

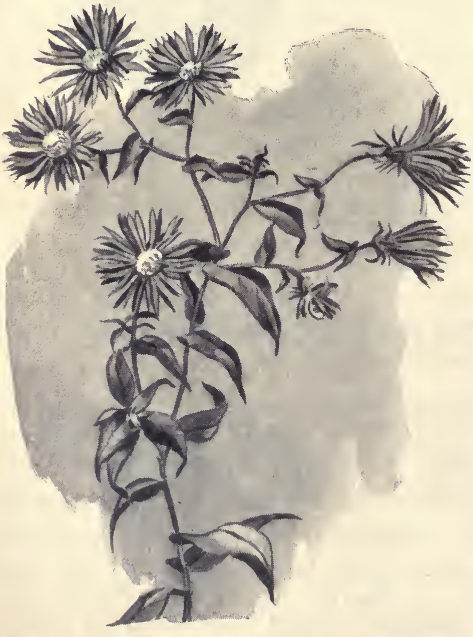


Fig. 10. The aster, a common and beautiful wild flower.

asters (Fig. 10)
boneset
clovers
daisies
goldenrods
joe-pye weed
lobelia
snakeroot
tall bellflower
thistles
toadflax
wild sunflower

2. Find as many of these wild flowers as you can. Whenever you find one, put a check before the name in the list in your science notebook and write after the name the color of the flower. **3.** Write in your book the names of any flowers you find that are not in this list. **4.** Make a list of those flowers you find growing in shady places, and another list of those growing in open, sunny places.

Project 14 (G). Observing the differences by which two flowers may be told apart. (Any two flowers may be selected.)

1. How do the flowers differ in color? In size? In the way they are placed on the stem? In odor? **2.** How do the leaves differ in size? In shape? **3.** Which is the taller of the two plants? **4.** Which do you think is the more attractive flower? Why?

Project 15 (G). Playing games with flowers.

Gather bouquets of many kinds of flowers, both wild and cultivated.

Game 1. The flowers are placed separately about the room and numbered. Each child, with pencil and paper, writes the numbers and opposite each number the name of its flower. The papers are then examined by the teacher.

Game 2. The flowers are placed loosely on a table. The teacher calls upon some pupil to come up and pick out a certain flower. If he makes a mistake, the others are to correct him. The other pupils are then asked in turn to pick out different flowers. A record is kept to see who picks out the most correctly.

Game 3. The flowers are arranged separately around the room. The names of the flowers are written on separate slips of paper. The children take turns drawing a slip and placing it beside the proper flower. The purpose of the game is to see which child can match the largest number of flowers and slips correctly.

Game 4. The teacher pins a flower on the back of some pupil, showing the flower to the rest of the class. The child asks questions about the flower of anyone he wishes — questions about its color, size, shape, etc. — until he can guess its name.

Game 5. A pupil takes a bouquet in his hand and stands before the class. He picks out one flower at a time, holding it up and naming it. He proceeds in this manner until he makes a mistake. The one who first corrects the mistake takes the bouquet and goes on with the game.

Game 6. A pupil stands before the class and describes some flower. The children try to guess the flower from the description. The child who first guesses it takes his turn in describing a flower.

Project 16 (G). Observing the differences in similar kinds of flowers.

1. Gather as many kinds of goldenrod as you can and notice how they differ with regard to the flowers, the leaves, and the height of the plants. **2.** Follow the same plan with the clovers. **3.** Compare the wild and the cultivated asters. In what ways are they similar? In what ways different?

B. Mushrooms

The flower is only one part of the whole plant, for in addition there are the leaves, stem, and seeds. The flowers exist for the purpose of forming seeds, which are to grow and form new plants. There are some plants that do not form flowers and seeds but grow new plants in a different way. These are sometimes called flowerless plants. Among the most interesting of these are the *mushrooms.*

The kinds of mushrooms. There are many kinds of mushrooms. You probably are familiar with the *puffballs*, which at first are white inside and then later turn to a fine dark dust that "puffs" out of the puffball when squeezed. (Fig. 11 *e*) Another group might be called the *umbrella* mushrooms because they have a stalk and cap that together look something like an umbrella. By the appearance of the under side of the cap you may recognize three kinds of these mushrooms: gill, pore, and spine mushrooms.

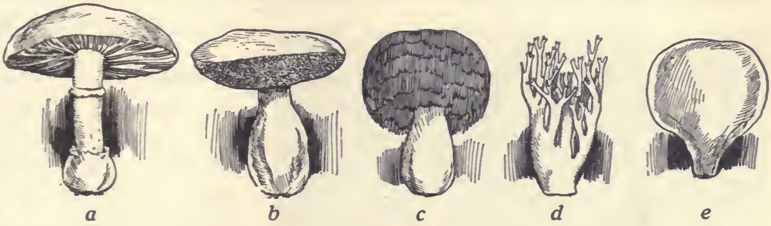


Fig. 11. Some common mushrooms.

The *gill* mushrooms have thin, gill-like plates that extend from the center outward, like the spokes of a wheel. (Fig. 11 *a*) Some of these gills are white, some pink, some brown, and some still other colors. The *pore* mushrooms have a great many small holes scattered over the under side of the cap. (Fig. 11 *b*) The *spine*, or hedgehog, mushrooms have little spinelike projections hanging down from the under side of the cap. (Fig. 11 *c*) Still another kind of mushroom is known as the *coral* mushroom, because it has a branching, coral-like appearance. (Fig. 11 *d*)

What do mushrooms live upon? Although the various kinds of mushrooms differ greatly in appearance, they are all alike in one respect: none of them contain any green matter such as is found in leaves. This green matter, called *chlorophyll*, is what makes food for the plant. Since the mushrooms do not contain this chlorophyll, they cannot make their own food but are obliged to live on other plants and animals. Those that live on dead plants and animals are called *saprophytes;* those that live on living forms are called *parasites*. While mushrooms are found growing up out of soil like other plants, in every case there is some form of dead animal or plant matter in the soil on which the mushroom is living.

How do new mushrooms grow? New mushrooms are produced by means of spores, and hence these plants are sometimes called *spore-bearers*. These spores are tiny, ball-shaped objects, so small that you cannot see just one spore by itself without using the microscope. The powder which you see in puffballs is made up of millions of these small spores. Under proper conditions, each of these spores grows into a new plant. In the umbrella mushrooms the spores are borne on the under side of the cap — on the gills and spines and in the pores.

Cultivated mushrooms are of interest because some of them are good to eat and can be bought in the market. Some of the wild mushrooms are also edible. But since some of them are poisonous, it is not safe to collect them for eating. There is no danger, however, in collecting and handling them for the sake of studying them.

Project 17 (G). Making a collection of mushrooms.

1. Collect as many kinds of mushrooms as you can find. **2.** See how many different kinds you have. Which are the most common? How do they differ in shape, size, and parts? **3.** Study and make drawings in your science notebook while your mushrooms are still fresh. Label the parts to correspond with Figure 13. **4.** Other kinds, such as the shelf mushrooms found growing on

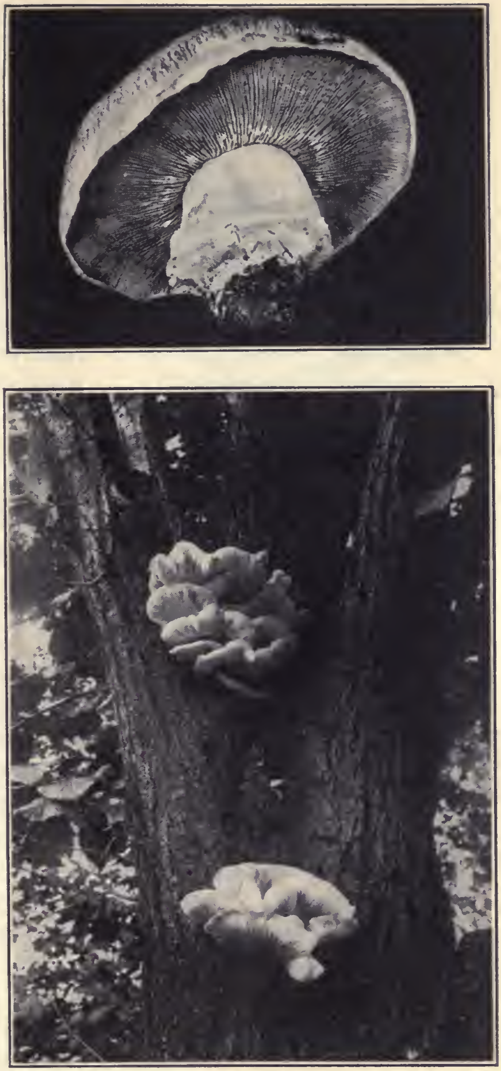


Photo by Brown Brothers, N. Y.

Fig. 12. A market mushroom (above). Shelf mushrooms (below).

stumps of trees (Fig. 12 below), can be kept for a long while. Put these in the school museum.

Project 18 (G). Making a collection of spore prints of mushrooms.

1. Take an ordinary piece of typewriting paper and spread mucilage over its entire surface. Allow it to dry and then cut it up into pieces about four inches square. **2.** Bring in as many of the gill-bearing mushrooms as you can find. Cut off the stem of each mushroom near the cap and place the cap, gills down, on a piece of the paper already prepared. The spores will fall down and be held on the paper by the mucilage. The spores of the various mushrooms differ in color. See how many differently colored spore prints you can collect. **3.** Glue a few of these pieces of paper in your science notebook.

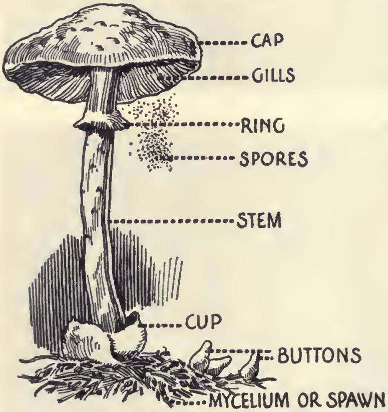


Fig. 13. A gill mushroom with parts named.

C. Ferns

Ferns are attractive on account of their beautiful leaves. (Fig. 14) For this reason they are often used as house plants or planted outdoors in the yard. Many of them do well in shady locations, where most other plants do not thrive. They are commonly found growing wild in damp, shady places.

Ferns reproduce by means of spores, which are often borne on the under side of the leaves. When these spores fall to the ground, they do not grow at once to form an ordinary fern plant. First they form a small, leaflike structure lying flat on the ground, from which the ordinary plant develops later.

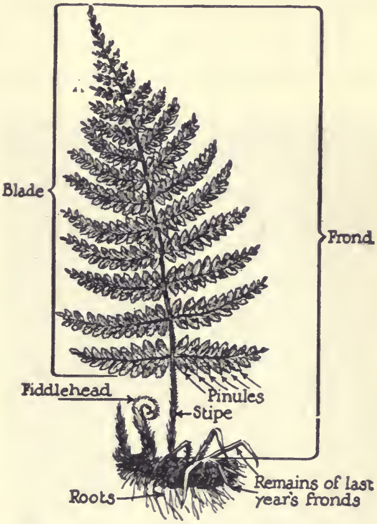


Fig. 14. A fern with parts named.

Project 19 (G). Making a collection of ferns.

1. You can make a collection for the school museum by bringing as many different kinds of ferns as you can find. Place the *fronds* (that is, the leaves with stems) between the leaves of a magazine and put some weight, such as old flatirons or books, on top. Allow them to stand about two weeks. **2.** To mount the ferns, secure pieces of heavy paper a little larger than the ferns. Fasten the ferns to the paper by means of strips of gummed paper. **3.** Mount some of the ferns with the under side up, so as to show the spores.

D. WEEDS

How are weeds harmful? If you have ever had a garden, you will remember how hard you had to work to keep the weeds out of it. Weeds do not produce any useful vegetables; they just rob the plants that are near them of water and food in the soil, and crowd them. No vegetables or flowers grow well if there are many weeds in the garden.

Weed seeds are a great trouble to the farmer, for they lower the price of his grain. When he takes it to market, if the buyer finds that it contains many weed seeds, he does not pay the farmer as much for his grain as he otherwise would.

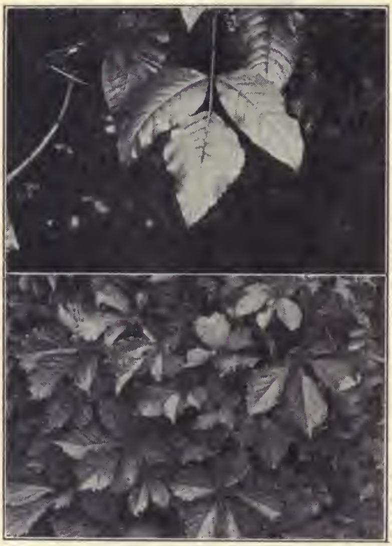


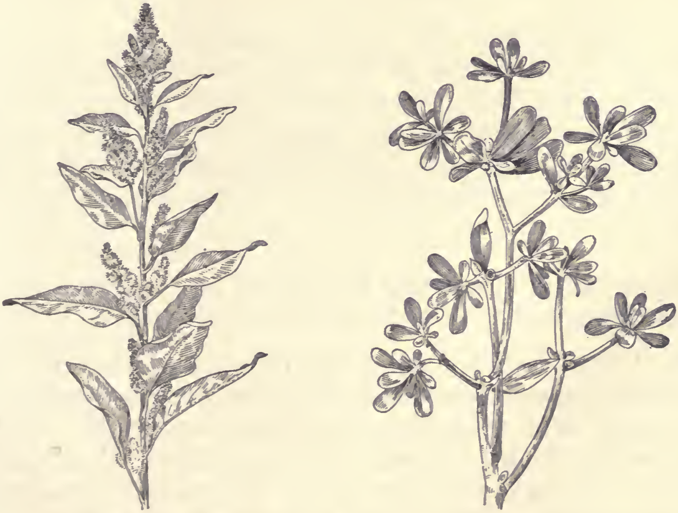
Photo by J. Horace McFarland Co., Harrisburg, Pa.

Fig. 15. Poison ivy (above); woodbine (below). Though they look somewhat alike, the leaf of the poison ivy has three, the leaf of the woodbine five leaflets.

Then, too, there are weeds that are poisonous to touch. Poison ivy is one of the most common of poisonous weeds. (Fig. 15) If one is poisoned with ivy, washing thoroughly with soap will help somewhat.

How may weeds be killed? A good way to fight weeds in the garden is to hoe the soil frequently. This is best done when the weeds are still small or even before they start to show above the ground. It is much less work to hoe a garden at this time than after the weeds are large and strong; and the harm that the weeds might do is prevented almost entirely. Weeds that grow around the edges of the garden, where they cannot be hoed, should be cut off before they go to seed. Otherwise the seeds will drop or blow into the garden, and you will soon have more weeds to fight.

When a few plants of some weeds get into the lawn, they may be killed by injecting gasoline or kerosene around the roots. An extremely troublesome patch of weeds may be killed by smothering them with tar paper. However, every other plant under the paper will be killed at the same time. Some weeds are annuals; others, perennials. The latter class are more difficult to control, because not only must the plant be prevented from going to seed, but the underground parts must be killed.



Rough Pigweed *Purslane*

Fig. 16. Two common garden weeds.

Project 20 (G). Learning how to tell rough pigweed (Fig. 16) **from lamb's-quarters. (Any two weeds may be taken.)**

1. How do the leaves of the two plants differ in shape and size? **2.** How do the plants differ with respect to their fruit and seeds? **3.** How do the plants differ in height? **4.** Make a drawing of a leaf from each in your science notebook.

Project 21 (I). Learning to name some of the common weeds.

1. Following is a list of fifteen common weeds. Copy the list in your science notebook in one column on the left.

barnyard grass
burdock
crab grass
dandelion
dock
foxtail grass
knot weed
lamb's-quarters
mallow
mustard
prostrate pigweed
purslane
quack grass
ragweed
rough pigweed

2. Look in gardens, by the roadside, and in vacant lots to see how many of the above weeds you can find. When you find one, put a check before the name in your list and write after it the place in which you found it growing. **3.** See how many weeds you can find that are not given in the above list. Add their names to the list.

Project 22 (G). Learning how poison ivy and woodbine can be told apart.

1. Poison ivy is such a common plant that you will want to know it so that you can avoid touching it. Although it is often confused with woodbine, the two can easily be told apart. **2.** Specimens of woodbine should first be secured and then the class, accompanied by the teacher, may go to a place where poison ivy is growing. **3.** Notice how the two plants differ on the following points: *A*. Leaves. *a*. Number of leaflets. A leaflet is the name given to one of the parts of a compound leaf, that is, a leaf made up of several blades each of which looks like a leaf. *b*. Margin of leaflets. *c*. Size and shape of leaflets. *d*. Petioles or stems of leaflets. *B*. Color of fruit. *C*. Height to which the plants grow.

Project 23 (G). Making a collection of weed seeds found growing in the garden, in vacant lots, or by the roadside.

1. It will be well if the class is divided into three groups, each group to explore one of the ranges suggested above. **2.** Each group should secure a piece of heavy cardboard about a foot long. One group should write across the top of the cardboard, *Seeds of Weeds Growing in the Garden*. A second group should write, *Seeds of Weeds Growing in Vacant Lots*. The third group should write, *Seeds of Weeds Growing by the Roadside*. **3.** Bring in seeds from each locality. In order to mount them place the cardboard in a horizontal position and put small drops of glue at regular intervals on it. Sprinkle a few seeds on each drop — a different kind for each drop — and allow the card to lie till the glue hardens. The name of the seeds may be written beneath each kind. **4.** In place of the cardboard a piece of glass may be used.

Project 24 (G). Estimating the number of seeds borne by a single plant.

1. Bring to school entire plants of several kinds of weeds. The class should be divided into as many groups as there are kinds of weeds. Or, if the plant is very large, the entire class may work on one plant. Each child then estimates the number of seeds in a portion of the plant. The results are all written on the blackboard and added to find the total. **2.** If each of these seeds grew next year to form a plant bearing as many seeds as this one, how many seeds would there be? **3.** Notice a growing weed plant and estimate the area in square feet that it covers. At this rate what area would the plants growing from the seeds estimated in question **2** occupy?

E. TREES

Why do you like trees? Because they are beautiful, perhaps, or because you have fun with them. You hang your swings from their branches or build houses high among the limbs. In the autumn you play with the fallen leaves, gathering them in great piles and

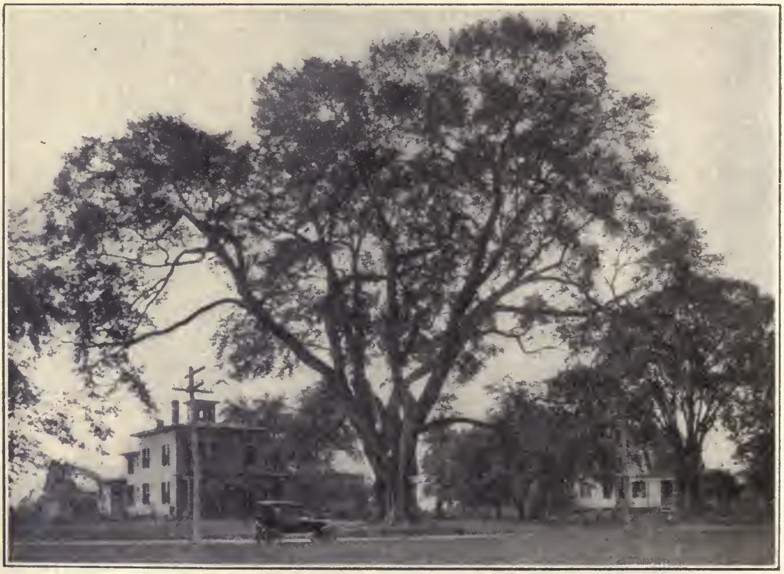


Photo by Ewing Galloway, N. Y.

Fig. 17. The elm, a graceful shade tree.

tumbling about in them. Before these leaves fall, they furnish you with shade during the hot summer months. Trees add greatly to the attractiveness of a yard or a street. (Fig. 17)

How to learn the names of trees. Probably the easiest way to tell trees apart is by their leaves. Since no two kinds of trees have leaves that are exactly alike, you will be able to name trees by observing their leaves. Leaves differ in the following ways: in shape, margin, veining, arrangement, and kind.

Shape. The chief difference in the shape of leaves lies in the number of times the length is greater than the breadth. Some leaves are long and narrow, while others are broad and roundish.

Margin. The edge of the leaf is called the margin. Sometimes this is entirely smooth (Fig. 18, Catalpa); again it may be toothed (Fig. 18, Beech); or it may be lobed (Fig. 18, Oak).

Veining. Three types of veining are commonly found in leaves. In the *pinnate* type there is one large vein, called a *midrib*, running down through the center of the leaf, with many small branches on each side, giving the appearance of a feather (Fig. 18, Chestnut). In another type, called the *palmate*, there are several veins of about equal size given off from the base of the leaf, like fingers from the palm of the hand or spokes from the hub of a wheel (Fig. 18, Sweet Gum). Sometimes the veins all run lengthwise of the leaf and are nearly parallel from end to end.

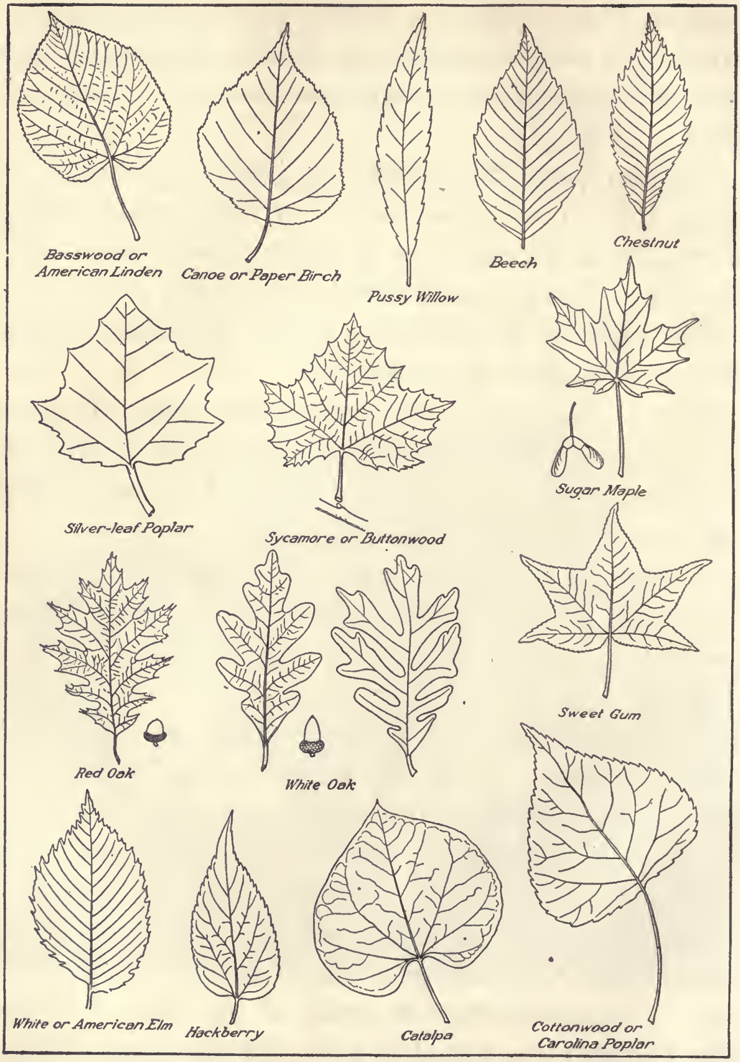

Basswood or American Linden
Canoe or Paper Birch
Pussy Willow
Beech
Chestnut
Sugar Maple
Silver-leaf Poplar
Sycamore or Buttonwood
Sweet Gum
Red Oak
White Oak
White or American Elm
Hackberry
Catalpa
Cottonwood or Carolina Poplar

Fig. 18. Some simple leaves.

Arrangement. This is the way the leaves are placed on the stem. There are two chief kinds of arrangement, opposite and alternate. In the first type the leaves are placed in pairs, one on each side of the stem, and exactly opposite each other (Fig. 19, *a* and *b*). Any other way of placing is called alternate (Fig. 19, *c*).

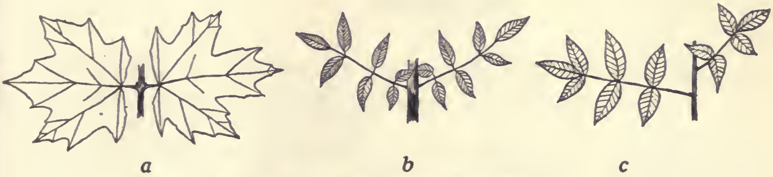


Fig. 19. Arrangement of leaves.

Kind. There are two kinds of leaves, *simple* and *compound.* A simple leaf consists of just one blade (Fig. 20). A compound leaf is composed of several blades or parts called *leaflets,* each looking like a complete leaf (Fig. 21). A person can tell whether a leaf is simple or compound by finding the buds. If each blade has a bud where the stem, or *petiole,* joins the branch, then each is a simple leaf. On the other hand, if each blade does not have a bud where the petiole joins the branch, then each blade is a leaflet, and the whole leaf

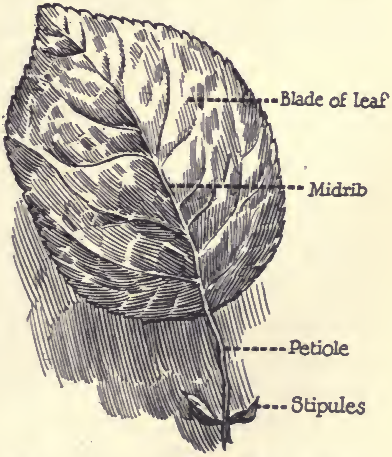


Fig. 20. A simple leaf with parts named.

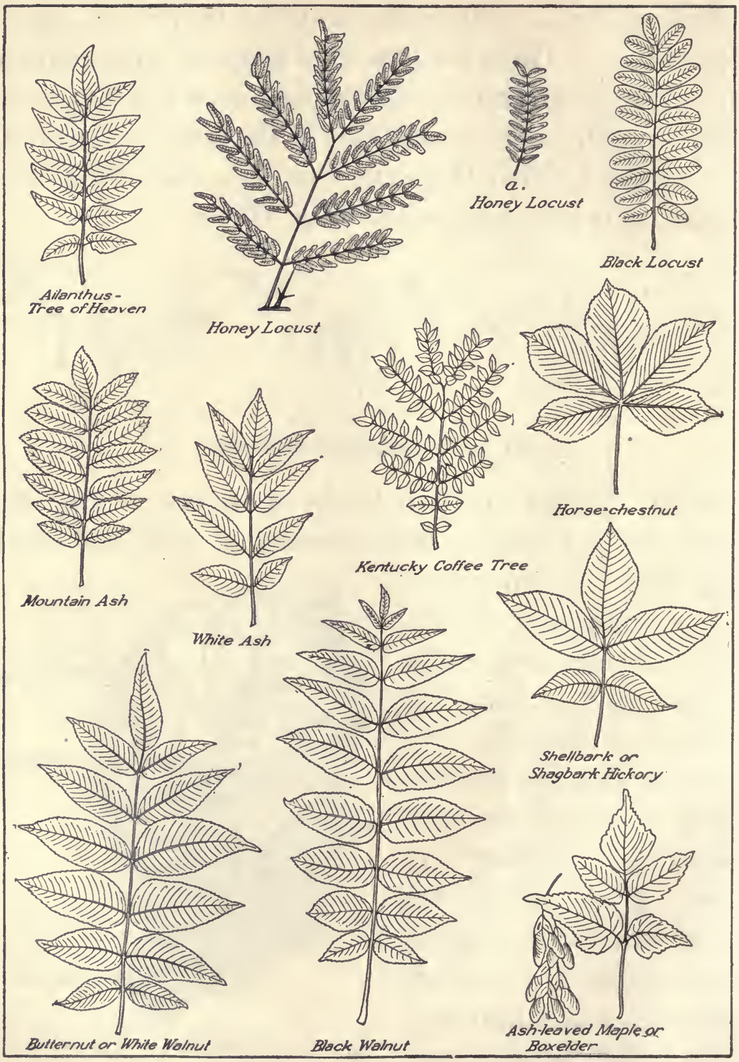

Ailanthus - Tree of Heaven
Honey Locust
a. Honey Locust
Black Locust
Mountain Ash
White Ash
Kentucky Coffee Tree
Horse-chestnut
Shellbark or Shagbark Hickory
Butternut or White Walnut
Black Walnut
Ash-leaved Maple or Boxelder

Fig. 21. Some compound leaves.

is compound. The leaf begins at the point where the bud is found.

Autumn is one of the best seasons to study leaves. When they fall from the trees, you can pick them up easily and make many interesting collections in varied colors.

Project 25 (G). Telling the oak and butternut trees apart by means of their leaves. (Any two trees may be chosen.)

1. Secure a cluster of leaves from both an oak tree and a butternut tree and bring to the schoolroom. **2.** How do the leaves differ in shape? How are the margins different? Is there any difference in the veining? **3.** Are the leaves simple or compound? Is there any difference in the way the leaves are arranged on the stem? **4.** Make a drawing of each leaf in your science notebook.

Project 26 (G). Studying the maple family of trees. (Or the oak family.)

1. Bring to the schoolroom leaves of as many different maples as you can find, such as the sugar, red, and silver-leafed maples and the box elder, which is a kind of maple. **2.** Notice first in how far the leaves are similar in shape, margin, veining, and arrangement. If you can find the fruits, notice in how far these are similar. These similarities of leaves and fruits show that these trees belong to the same family. **3.** How can you tell the maples apart? In what ways do the leaves differ in margin and shape? **4.** Make a drawing in your science notebook of a leaf of each kind of maple.

Project 27 (G). Studying the shade trees of your city.

1. Following is a list of some of the common shade trees growing in the northern and eastern United States. Copy the list in your science notebook in one column on the left.

ash
box elder
butternut
catalpa
cottonwood
elm
hackberry
linden
locust
sugar maple
silver-leafed maple
bur oak
red oak
walnut

2. Find out by observation and by inquiry which of these trees are growing in your city. Put a check before the name of each in your science notebook. **3.** If you find any that are not in the above list, write the names in your book. **4.** Which make the best shade trees? Why? **5.** Notice whether the shade trees of your city are receiving the proper care. Are the young trees protected by a guard? When the limbs are trimmed off, are they cut off correctly, or has a long stub been left sticking out? Are the cavities in the tree trunks properly looked after? How?

6. Are there any streets where more trees should be planted? **7.** Make a map of the streets in the block in which your school is situated. On the map put a small circle for every tree growing there. By the side of each circle write the name of the tree.

8. You can find the height of a tree in the following way. This method can be used only on a sunny day when the tree casts a shadow. Measure the length of the tree's shadow. Set up a stick about ten feet long in the ground. Measure the length of the stick and also of its shadow. Multiply the length of the stick by the length of the tree's shadow. Divide this product by the length of the stick's shadow. The quotient is the height of the tree.

Project 28 (G). Making a calendar of the coloring of leaves.

1. Secure a large sheet of heavy paper and place around the margin decorations suggestive of autumn leaves. **2.** Copy the headings given below at the top of the sheet. At least once a week report your observations and fill in the calendar.

CALENDAR OF LEAF COLORING

Name of tree	Date of first colors seen	Colors seen	Location of tree	Name of child first reporting

3. Make a small copy of the calendar in your science notebook.

Project 29 (G). Making a collection of all kinds of tree leaves.

1. On pages 40–41 you will find descriptions of games to be played with leaves. To play these games it will be necessary first for you to collect and mount the leaves, so that they can be easily handled. **2.** Begin to make your collection about the time that the leaves commence to color and fall. Get as many different kinds of leaves as you can. **3.** Put the leaves between the pages of an old book, magazine, or the folds of a newspaper and then put some weights on top to press them. Let them stay there about a week. **4.** To mount the leaves, secure pieces of cardboard or heavy paper about six inches square. Place a leaf in the middle of the paper. Cut gummed paper into narrow strips and stick several of these over the edges of the leaf so as to fasten it securely to the paper. Figures 18 and 21 will help you find the names of the leaves.

Project 30 (G). Playing games with leaves.

Game 1. The cards are placed around the room and numbered. Each child takes a pencil and paper and writes the numbers, and after each number the name of the leaf. The papers are then examined by the teacher to see who has the most correct.

Game 2. One child stands before the class with all the cards on the desk before him. He holds them up one at a time and names them until a mistake is made. The child who first corrects the mistake then takes the cards and goes on until he makes a mistake. This game may be slightly changed as follows: Allow each child in turn to take the cards and name as many as he can. The one naming the most wins.

Game 3. The teacher pins one of the cards on a child's back and shows the card to the rest of the children. The child stands before the class and asks questions of first one and then another about the appearance of the leaf until he can name it. He then calls on someone else to take his place.

Game 4. The cards are placed along the blackboard railing. The names of the trees are written on separate slips of paper and placed on the table. The children take turns in drawing a slip and putting it beside the proper leaf. The child wins who matches the most correctly.

Game 5. The cards are placed on the blackboard railing. One child stands before the class and picks out in his own mind one leaf. The other children ask him questions about the leaf — its shape, margin, veining, etc. — until some one guesses the name. This one then takes his turn in thinking of a leaf.

Game 6. One game can be played like an old-fashioned spell-down. Two captains are selected, and these two choose sides. Then the two sides line up in two rows. The teacher shows the leaves in turn to each side. A child who makes a mistake goes to the other side. The side that has the most pupils when the leaves have all been named wins the game.

Project 31 (G). **Making a collection of prints of leaves.**

1. First secure a candle, some matches, a small quantity of fat, such as lard or crisco, pieces of ordinary white paper, a piece of cloth, and specimens of fresh leaves. **2.** On a piece of paper a little larger than the leaf rub a little fat. Hold this above the flame of the candle, moving it around so that it doesn't burn. Keep it moving till the fat melts. Then tip the paper on edge so that any excess fat may run off. **3.** Turn the paper over and hold the fatty side down in the flame so that soot collects over the paper as a thin coating. Keep the paper in motion so as to prevent its burning. **4.** Fold the cloth several times and lay it on the table. On this, place the paper sooty side up. Lay a leaf on this soot. On this leaf place another piece of paper. Press down on this paper with your fingers, rubbing them over it for about half a minute. **5.** Then remove the paper and lift up the leaf by the stem. Both pieces of paper may now be thrown away. You are now ready to make the print with the leaf. Put a piece of clean paper on the cloth. On this lay the leaf, sooty side down. Over this place a piece of paper and rub over it with the fingers. **6.** Now lift the top paper and the leaf and you will find a leaf print on the lower paper. Several prints may be made with the same leaf. This print is made with indelible ink and will keep a long time.

7. Perhaps the first print you make may not be very satisfactory; but after you try a few times, you will learn how. One thing to avoid is getting too much fat on the paper in the first place. Be sure to have a coat of soot over the entire surface of the first piece of paper.

8. Paste one of these prints in your science notebook. **9.** Make prints of as many kinds of shade-tree leaves as you can find growing in your city.

Project 32 (G). **Making a calendar of the falling leaves.**

1. Secure a large sheet of heavy paper. Around the border make decorations suggestive of autumn trees. **2.** Copy the following headings. Each week report your observations and fill in the calendar.

CALENDAR OF LEAF-FALL

Name of tree	Date first leaves fall	Date when all leaves have fallen	Name of child first reporting

3. Copy in your science notebook.

Project 33 (G). **Making a collection of tree seeds for the school museum.**

1. Bring in all the kinds of tree seeds you can find, such as those of the box elder, sugar maple, locust, ash, catalpa, and linden. **2.** By means of glue fasten these to a piece of cardboard and write across the top, *Seeds of Trees.* **3.** Make drawings of a few in your science notebook.

F. SEED TRAVELERS

A plant is fixed in one place during all of its growing life unless some human being transplants it. If it travels at all, it must do so during the seed stage.

Seeds may be scattered by the following means:

wind, water, animals, birds, man, and by the plant itself.

How are seeds scattered by the wind? Seeds are formed in such a way as to help the wind scatter them. (Fig. 22) Some, like the dandelion, have hairlike attachments by means of which they float in the air, much like a *parachute.* Others, like the milkweed, have thin wings by which the seeds sail along. In still other cases, as the tumbleweed, the whole plant, which is light and spherical in shape, breaks off near the ground and is rolled along by the wind, often for many miles, over level ground, scattering the seeds that are shaken out as it rolls.

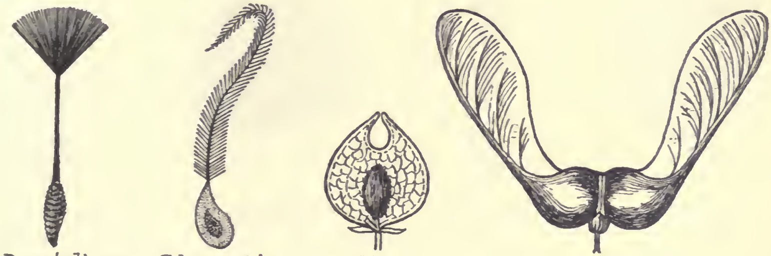
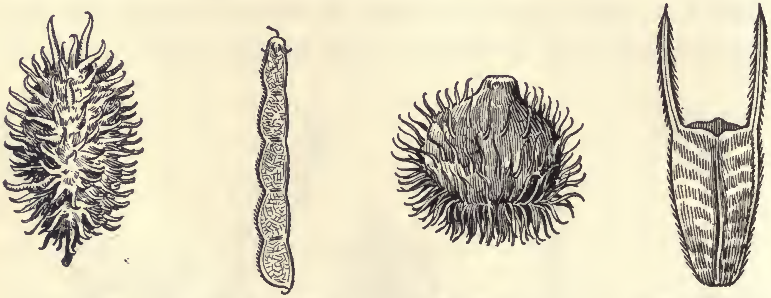

Dandelion Clematis Elm Maple

Fig. 22. Fruits and seeds scattered by wind. From Peabody and Hunt; *Biology and Human Welfare.*

How do animals scatter seeds? Seeds may be scattered by fur-bearing animals and by birds. Some seeds, like those of the pitchforks, have hooklike attachments by means of which they stick to the fur of animals. (Fig. 23) Squirrels store up piles of nuts for food, but sometimes do not eat them all, and the remainder may begin to grow in the spring. Water birds carry seeds in the mud that sticks to their feet as they fly from pond to pond.

How does man scatter seeds? Man himself is a common means of carrying seeds. Seeds of some of our worst weeds have been accidentally brought over from Europe, sometimes mixed with grain seeds, or in the packing placed around plants. Threshing machines are another means of spreading weed seeds.



Cocklebur **Tick Trefoil** **Burdock** **Beggar-ticks**

Fig. 23. Fruits and seeds scattered by animals. From Peabody and Hunt: *Biology and Human Welfare.*

How do plants scatter seeds? In some cases the plant that bears the seeds may scatter them itself. Sometimes, as the seeds ripen, the parts around the seeds give a sudden snap and throw out the seeds. This method is well illustrated by the touch-me-not. In other cases, plants bear seed boxes open at the top; and as the stem sways back and forth in the wind or is jarred by animals, the seeds are thrown out. The cone-bearing branches of the sugar pine even look as though they were trying to drop seed from their tips as far from the parent tree as possible.

Project 34 (G). Making a school collection of seeds to show how they are scattered.

1. Get two large pieces of heavy paper or cardboard. Across the top of one write, *Seeds That Fly.* Across the top of another, *Seeds That Steal a Ride.* **2.** Collect as many kinds of seeds as you can find. Put those scattered by the wind on the first chart; those on the second chart that have hooklike attachments or burs to make them stick to people's clothing or to the fur of animals. **3.** In order to fasten the seeds to the chart, lay the chart down flat and put small drops of glue on it and drop the seeds into the glue. Leave the chart till the glue hardens. **4.** You may also put the seeds in little vials which you can secure at a drug store. These vials may be fastened to a piece of cardboard by an elastic string.

CHAPTER III

SOME INTERESTING INSECTS

A. INSECT ACTIVITIES

Insects may be divided into two groups according to the way in which they grow up. The butterfly belongs to one group and the grasshopper to the other.

How does the butterfly grow up? The butterfly begins as a small egg, which hatches into a small caterpillar. This feeds and grows very rapidly by a process of *molting*. That is, the caterpillar grows faster than its skin, so that after a while the skin gets too small. The skin splits down the back, and the caterpillar crawls out. Each new skin is in turn molted or shed until the caterpillar is fully grown. The caterpillar stage is the only one in which the insect grows larger. The butterfly itself never grows any larger after it once appears.

In a few weeks or months the caterpillar becomes fully grown. It then changes into another stage called the *pupa*, or *chrysalis*, which is altogether different from the caterpillar. It can neither eat nor move about. It remains quiet in one place, often suspended by means of silken threads spun by the caterpillar. In some cases this stage may last only a few weeks; in others, it may persist through the winter. Finally, however, there comes out of this pupa a beautiful butterfly, so different from the crawling caterpillar in both appearance and habits that the change seems like magic.

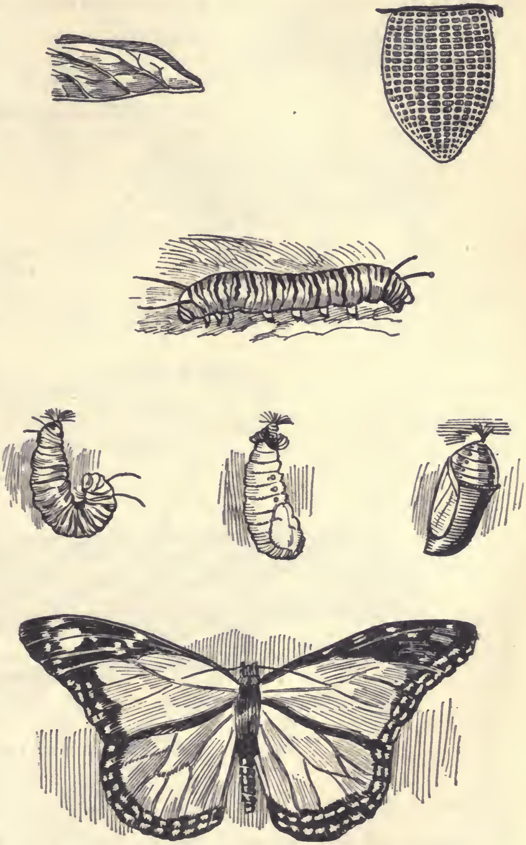


Fig. 24. Life history of milkweed butterfly.

The butterfly has four distinct stages: the *egg*, the *larva* (caterpillar), the *pupa*, and the *adult* (butterfly). (Fig. 24) Many other insects, such as moths, flies, beetles, and bees, pass through the same four stages. In different insects the larva is called by different names. (Fig. 25) The larva of a moth or a butterfly is called a caterpillar; the larva of a fly, a maggot; the larva of a beetle, a grub; the larva of a mosquito, a wiggler. The changes through which insects pass are called the *metamorphosis*.

How does the grasshopper grow up? Another group of insects, such as the grasshoppers, pass through three stages: the *egg*, the *nymph*, and the *adult*. (Fig. 26) The egg of the grasshopper hatches into a small insect called a nymph, which grows and molts its skin in much the same way as the caterpillar. This nymph looks very much like the adult, except that it is smaller and has no wings. These first appear as small pads, which

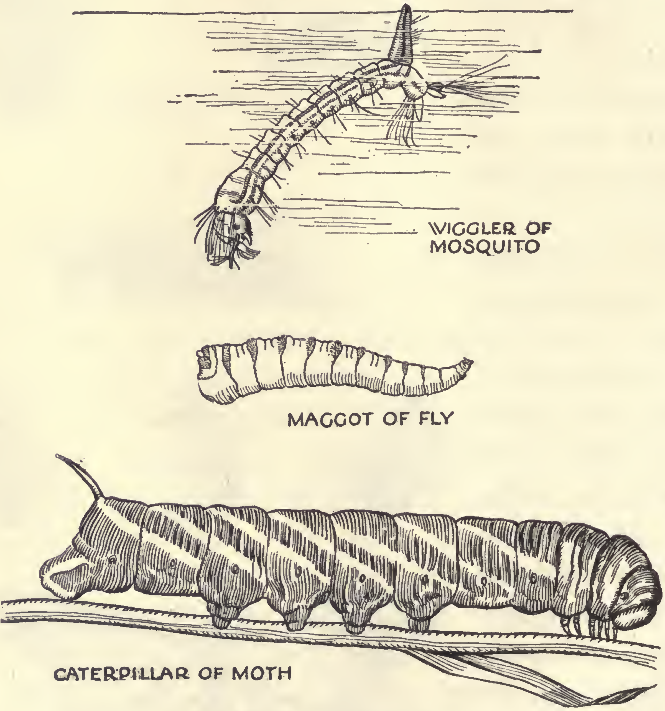


Fig. 25. Different kinds of larvæ.

gradually become larger as the insect molts. Other insects that pass through this incomplete metamorphosis are crickets and bugs.

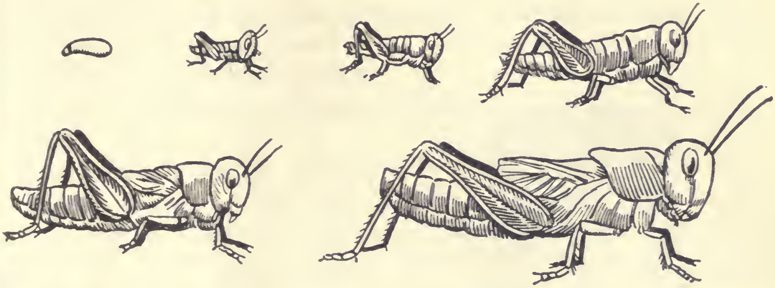


Fig. 26. Life history of grasshopper. Egg (upper left); five nymph stages. From Peabody and Hunt: *Biology and Human Welfare.*

Project 35 (g). **Making an insect net.**

1. Secure an old broom handle and a four-foot piece of stiff wire of about the size used for telephone lines. Bend this wire into the shape shown in Figure 27. Put the broom handle between the wires and fasten them by wrapping heavy twine around the handle. **2.** Fasten a piece of heavy cloth two or three inches wide around the wire. **3.** For the bag secure a piece of porous cloth, such as cotton net. Make this into a bag about thirty inches

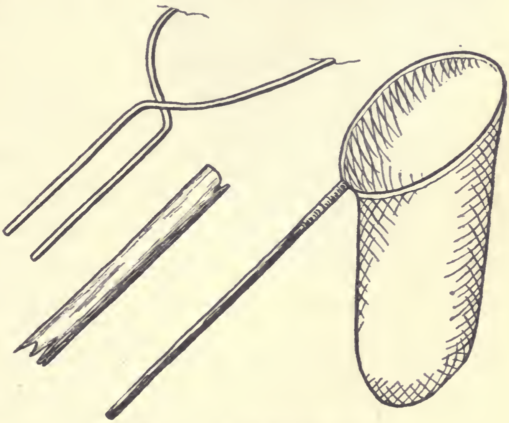


Fig. 27. An insect net.

long, rounded at the bottom. Fasten this bag to the cloth on the wire.

Project 36 (G). **Making an insect cage.**

1. Secure a flower pot and a lantern globe. Fill the pot nearly full of clean sand. Over the top of the lantern globe fasten a piece of mosquito netting by means of a rubber band. Then set the globe on the sand. (Fig. 28) **2.** Use a shoe box. In the cover cut a large hole. Cover this hole with a piece of mosquito netting, which may be sewed or glued to the cover. **3.** Still simpler cages may be made from glass canning jars, or a chalk box covered with a pane of glass.

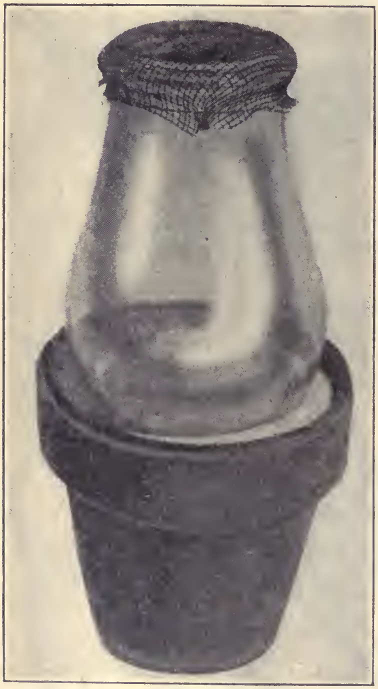


Fig. 28. A cage for rearing insects.

Project 37 (G). **Observing how insects grow up.**

1. Bring some caterpillars into the schoolroom and keep them in an insect cage. Milkweed or tomato caterpillars are very satisfactory for this purpose. Each day the cage should be cleaned and the caterpillars fed with fresh leaves of the plant on which they were found. If you are not sure, try leaves of cherry, clover, or grass. Feed the caterpillars till they pass into the pupa stage. How does this stage differ from the caterpillar? Keep this pupa till the adult comes out.

How does it differ from the caterpillar? In some cases this change does not take place till the following spring. Find a suitable place in which to keep these *pupæ* (pupas) during the winter, where they will be cool and fairly moist. Do not keep them in the schoolroom because the air is too dry. They may be placed in a chalk box fastened outside the window. During the winter collect cocoons outdoors and put them in this box.

2. Collect some very small grasshoppers and keep them in a cage. Feed them on grass. Get also a few large grasshoppers. How do the large ones differ from the smaller ones? Notice how the small ones change from week to week.

THE FEEDING OF INSECTS

How do insects eat? The mouth parts of insects may be divided into two classes according to the way they are used: (1) those used for biting; (2) those used for sucking. The mouth parts of a grasshopper are an example of the biting type. There is a single pair of *mandibles*, or jaws, which are toothlike in appearance and so arranged that they cut from side to side, instead of being one above the other, like your own teeth. (Fig. 29) By means of these mandibles grasshoppers are able to eat the leaves of plants. Other insects with biting mouth parts are the beetles and the caterpillars.

To the group of sucking insects belongs the moth, which has a long tube used for sucking nectar from the flowers. (Fig. 29) When not in use, this tube is coiled up like a watch spring. The mosquito has a mouth part adapted for piercing the skin and sucking the blood. Many insects, such as the squash bug, bore into the soft leaves and stems of plants and suck out the sap. The mouth parts of house flies are used to rasp or scrape food and to make it into a liquid before they suck it.

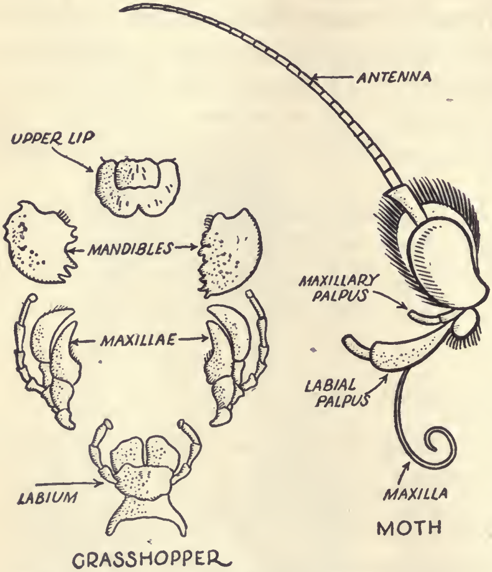


Fig. 29. Kinds of mouth parts among insects.

Project 38 (G). Observing how grasshoppers and butterflies eat.

1. Secure a grasshopper, a butterfly, and a bouquet of flowers and bring them into the schoolroom. Put the grasshopper in an ordinary insect cage. **2.** Take the butterfly by the folded wings and gently place it on the bouquet. Notice how it gets its food from the flowers. What sort of mouth part has it? How long is it? How does the butterfly use it? Can you see what the butterfly does with it when it is not in use? **3.** Put some grass in the grasshopper's cage and notice how it eats. What sort of mouth parts has it? How do they differ from those of the butterfly? How does the grasshopper use them?

THE BREATHING OF INSECTS

How do insects breathe? Insects have a peculiar method of breathing. The openings through which the air is taken are not in the head but in the *abdomen*. The grasshopper would not drown with just its head under water any more than a human being would drown with only his feet under water. The grasshopper has many openings through which the air is taken into the body. These are arranged on both sides of the abdomen and may number ten or twelve pairs. In the human body the air goes to the lungs and from there its *oxygen* is taken by the blood to various parts of the body. In insects there is a set of branching tubes called *tracheæ* (tracheas), which extend through all parts of the body; the air is taken by these tubes directly to the various parts.

Project 39 (G). **Observing how the grasshopper breathes.**

Catch a large grasshopper and put it into the cage until you are ready to study it. Then take it by the folded wings and look at the breathing motion of the abdomen. Find the little breathing pores along the sides of the abdomen. How many pairs do you find? Count the number of times the insect breathes in a minute and compare with the number of times you breathe in a minute.

THE TRAVELING OF INSECTS

In what ways can insects move about? Insects have different ways of moving, such as flying, jumping, crawling, running, and swimming. Nearly all insects have wings — usually two pairs of them — although some, like the fly, have only one pair. Some insects, such as butterflies and dragon flies, use all four wings for flying.

(Fig. 30) Other insects, such as grasshoppers and beetles, use only the hind pair in flying. In these insects the front pair of wings is much tougher and harder than the hind pair and serves to protect their bodies from harm. While flying, the front pair is held out of the way of the hind pair in order not to interfere with the movements. (Fig. 30, beetle)

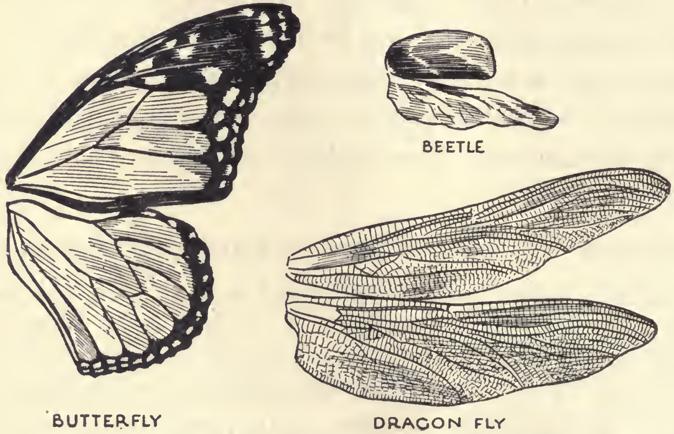


Fig. 30. Different kinds of wings among insects. These are not pairs of wings, but the two wings of one side.

Jumping is one of the chief ways of moving used by the grasshopper. It jumps by means of its hind pair of legs, which are much larger than the front legs. These jumping legs are very strong. Have you ever stopped to think how far a grasshopper can jump?

Project 40 (G). Observing how insects move.

1. *Flying.* To study the flight of insects secure a grasshopper and a butterfly. Let them fly around in the schoolroom. Notice the difference between the two with respect to the number of wings each uses. What difference is there in the way they use the first pair of wings? Notice how the grasshopper's first pair of wings differs from its second pair. Do you find the same difference between the two pairs of wings of the butterfly?

2. *Jumping.* Catch a grasshopper and let it loose in the schoolroom. Notice its method of jumping. What pair of legs is used? How does this pair differ from the other pairs?

Measure the distance the grasshopper jumps. Measure the length of its body. How many times its own length does the grasshopper jump? Measure the distance you can jump. How many times your height can you jump? How does this compare with the grasshopper? If you could jump as far in proportion to your height as the grasshopper can, how far could you jump? Work out the same sort of problem for the height of your jump and of the grasshopper's jump.

3. *Running.* Catch some active beetle like the ground beetle. Keep it in the schoolroom and watch it run. How many times its length can it run in ten seconds? Sometime when you are out of doors, see how many times your own length you can run in ten seconds. How many legs has the beetle? How do these differ from the jumping legs of a grasshopper?

4. *Crawling.* Catch a caterpillar and keep it in the schoolroom. Notice how it crawls. How many legs does it use? On what part of the body are these placed? Describe the motion of the body while the caterpillar is crawling.

5. *Swimming.* Catch some water insects such as a backswimmer, a water boatman, or a water beetle. (Fig. 61) Keep them in a glass jar filled with water. Notice how they swim. How many legs have they?

Which ones are used in swimming? How are these legs formed to be used as oars?

THE SINGING OF INSECTS

How do insects sing? The chief thing of interest about the sounds of insects (for they are hardly music) is the way in which they are made. They are never made by the mouth. Different insects make their sounds in different ways. Some, such as a few grasshoppers, make them by rubbing the two pairs of wings together as they fly. Some, like other grasshoppers, make their music by rubbing the leg over the wing and are often called "little fiddlers." One of the commonest methods is by rubbing the two wings of the front pair together. Among the crickets and grasshoppers the bases of the front pair of wings have special tambourine-like spots and roughened edges which, when the two wings are rubbed together, produce the vibrations that cause the sound. (Fig. 31 *a* and *b*)

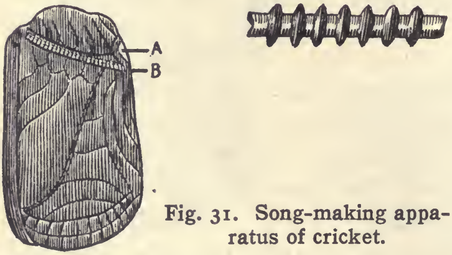


Fig. 31. Song-making apparatus of cricket.

One specially interesting insect of this sort is the snowy tree cricket. The night song of this insect sounds like the two syllables *te-reet′*, which come in beats accented on the second syllable, so that one can usually count the number of beats in a minute. The peculiar feature of this insect is that the hotter the night the faster it sings. (Fig. 32)

Project 41 (I). **Studying the song of the snowy tree cricket.**

1. By counting the number of beats that this insect makes in a minute you can tell about what the reading of a thermometer is. **2.** Some evening just after sunset take a watch in your hand and count the number of beats that the insect makes in a half minute. Then multiply this result by 2 in order to get the number of beats it makes in a minute. For example, if you counted 70 beats in a half minute, then 140 would be the number of beats in a minute. **3.** From this number subtract 40. In this case, 140 minus 40 equals 100. Divide this number by 4. In this case, 100 divided by 4 equals 25. Finally add the number you get to 50. In this case, 25 added to 50 equals 75. This number represents the temperature. Look at the thermometer and see what it reads. **4.** Try this experiment on a cool night and again on a very warm night. How near do your results come to the real temperature in each case, as recorded on a thermometer?

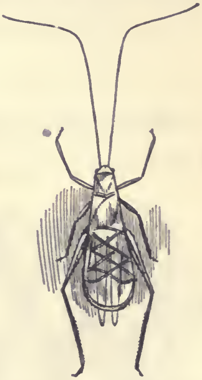


Fig. 32. Snowy tree cricket, an insect musician. The hotter the night, the faster he sings.

Project 42 (G). **Observing how crickets and grasshoppers make their sounds.**

1. Catch several crickets and green grasshoppers and put them in an insect cage in the schoolroom, in a sunny position, and keep them supplied daily with fresh grass. **2.** Whenever you hear the insects make any sound, watch to see how they do it. What part of the body moves, and how does it move? Look closely at the base of the wings and see whether you can find any special structure that might help in making the sound. Look at the wing through a reading glass. What does the noise sound like? **3.** When do they sing more — on a cloudy day or a sunny day? **4.** If you hear both insects (the cricket and the grasshopper) sing, notice how the sounds differ.

THE SIGHT OF INSECTS

What kind of eyes do insects have? For seeing, insects have what is called a *compound* eye — that is, one made up of many simple eyes, called *facets*. (Fig. 33) Some insects have thousands of these facets. Perhaps you will think that, with a thousand eyes, an insect must have unusually keen eyesight; but, as a matter of fact, it is much poorer than yours, because each facet is very imperfect and can only see straight in front of it. In order that an insect may see all of a stick, the images from many of these simple eyes must be joined together.

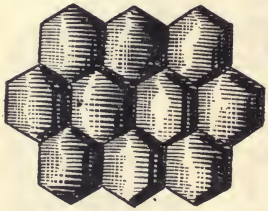


Fig. 33. A part of the compound eye of an insect, enlarged.

THE HEARING OF INSECTS

The sense of hearing among the insects seems to be imperfect. The ear is not on the head of the insect but on different parts of the body, depending on the kind

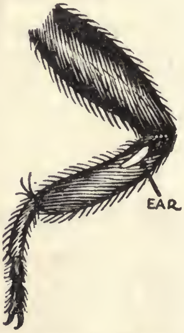


Fig. 34. Ear of cricket located on front leg.

of insect. The ear of the cricket is located on the joint of one of the legs. (Fig. 34)

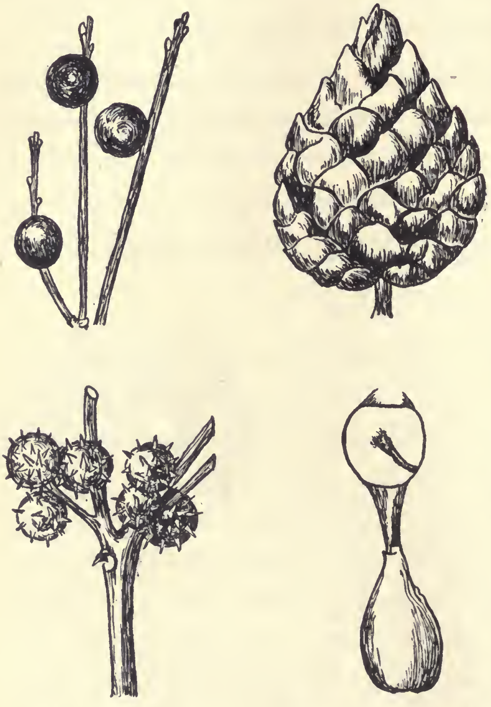
THE SMELLING OF INSECTS

The sense of smell seems to be well developed among those insects that visit flowers to get pollen and nectar. Probably a bee can smell a flower before it can see it. In some insects the sense of smell is located in one of the joints of the feelers, which are threadlike objects found on the head.

B. GALLS

How are galls made? Insects live in a great variety of places and use many kinds of houses in which to make their homes. Some build their own houses — the hornets out of crude paper, the mud dauber out of mud, the honeybee out of wax. Other insects lay their eggs on the stem of some plant; then when an egg hatches, the young insect so irritates the plant that a swelling, called a gall, appears on the stem. In this swelling the insect lives and gets its food. The insect did not make the swelling, but it caused the plant to make it. Galls such as these are found not only on stems of plants, but also on leaves and roots. You will find them on many different kinds of plants; you will see that they differ in size and shape according to the plant and insect. They are especially abundant on oaks, willows, and goldenrods. (Fig. 35)

There are very curious facts to notice about these galls. One is that a certain kind of insect seeks a certain kind of plant upon which to lay its eggs. For example, there is a little moth that always seeks out the goldenrod and lays its eggs on the stem. You will observe that this gall is oval in shape, about an inch long; and the hundreds of these that you may find will all be about the same size and shape.



Oak bullet gall Willow pine-cone gall
Spiny rose gall Goldenrod ball gall

Fig. 35. A group of galls.

Project 43 (G). Making a collection of insect galls for the school museum.

1. Galls may be easily collected in the autumn after the leaves have fallen. They are easily seen then and the insects have left them. **2.** Look on all kinds of plants for irregular swellings, especially on oaks, willows, rose bushes, and goldenrod. See how many different kinds you and your classmates can collect. **3.** Label each gall for two things: (1) the name of the plant on which it was found; and (2) the part of the plant on which it was found, whether the leaf, the root, or the stem. **4.** After you have made the collection, study the different galls.

Take them, two at a time, and notice how they differ in size, shape, and color. **5.** Make drawings in your science notebook of the different kinds of galls.

C. Social Insects

Some insects, such as bees, ants, and wasps, are called *social* insects because they live together in colonies. Among these social colonies are found insects with interesting and wonderful habits.

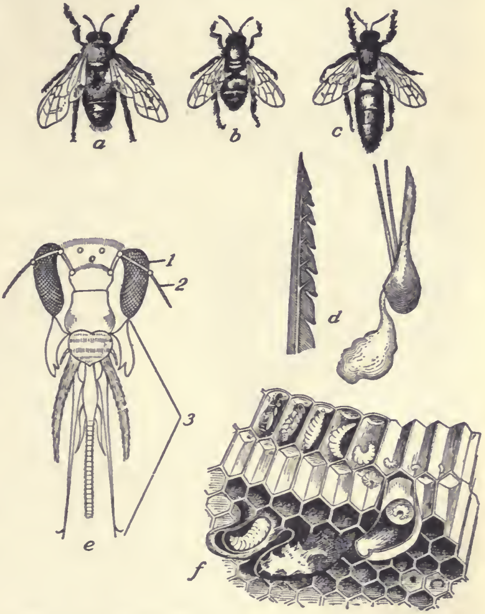


Fig. 36. Honeybee: *a*, drone; *b*, worker; *c*, queen; *d*, sting; *e*, head of worker, *1*, compound eyes, *2*, antenna, *3*, mouth parts; *f*, comb with larvæ, the larger cells being queen cells.

HONEYBEES

How do young bees grow up? A colony of bees contains three kinds of individuals (Fig. 36): one queen, several hundred drones, and from fifteen to thirty thousand workers. The work of the queen is to lay eggs, as many as one thousand in a day. These are laid in little cells in the comb — one egg to each cell. After the eggs hatch, the larvæ are fed by the workers. At first they are fed with a rich food called bee jelly.

Later most of them are fed with honey and beebread and develop into workers.

After the larva stops growing, it passes into the pupa stage. In about two weeks the adult bee comes out of the pupa and joins the rest of the colony. The work of the newly hatched worker is to help feed the growing larvæ. As the workers get older, they go out and help gather food. However, if the workers wish a queen, a larva is fed upon the rich bee jelly all the time; thus finally a queen is produced instead of a worker.

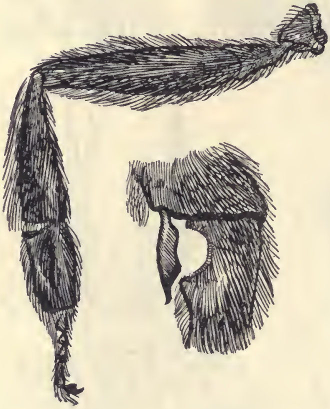


Fig. 37. Legs of worker honeybee.

What kinds of food do bees eat? Bees find in flowers two materials which are made into foods, namely: nectar and pollen. The nectar is sucked up by the bee into a honey sac, where it is changed into honey, and then stored in the cells of the comb. The pollen is carried by the bees on little segments of the hind legs with the help of a fringe of stiff hairs. These organs are called pollen baskets. (Fig. 37) This pollen is taken to the hive (Fig. 38), where it is used for food. When you see bees around flowers, you know that they are getting food; and if you look closely, you may be able to see their pollen baskets filled with yellowish masses of pollen.

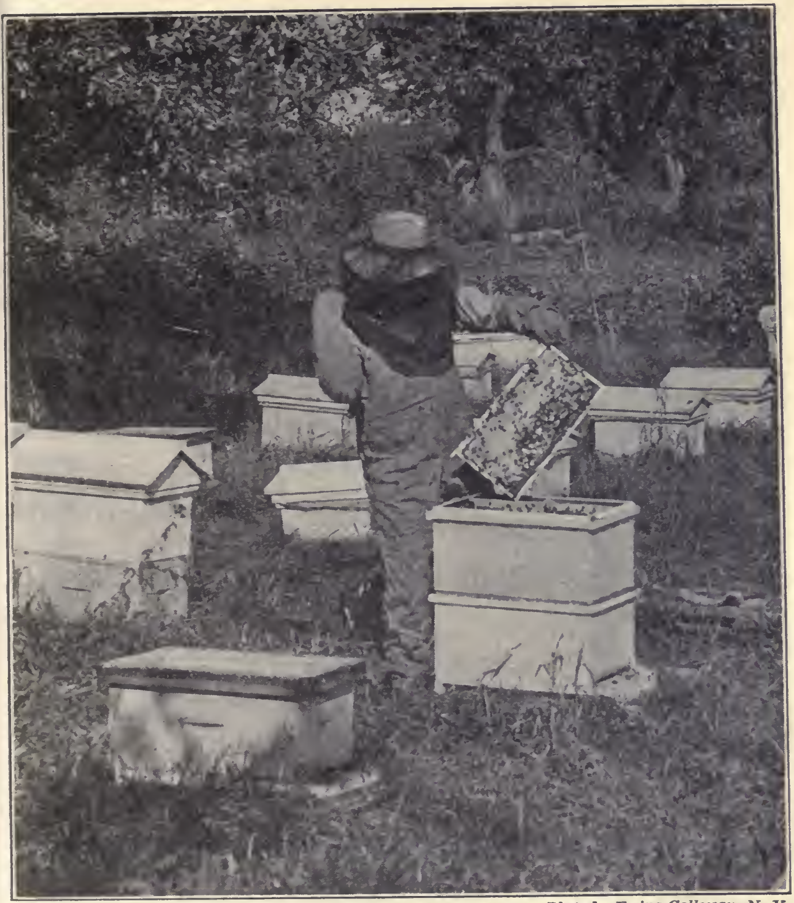


Photo by Ewing Galloway, N. Y.

Fig. 38. Hives for bees.

WASPS

There are many different kinds of wasps, of which we shall describe two: the paper wasp, or hornet, and the mud dauber.

How do hornets live? Among the paper wasps the queen is the only one that lives through the winter. In the spring she makes a small nest. This consists of a comb of cells opening downward, surrounded with a covering on the outside like a bowl. In each of these cells the queen lays an egg. When these eggs hatch out, she feeds the larvæ, which eventually become full-grown adult wasps. These now do the work of enlarging the nest and feeding the young, while the queen lays more eggs. As the colony increases in numbers, the nest is made larger; the combs are extended outward. New combs are also made one above the other like the different floors in a house. (Fig. 39)

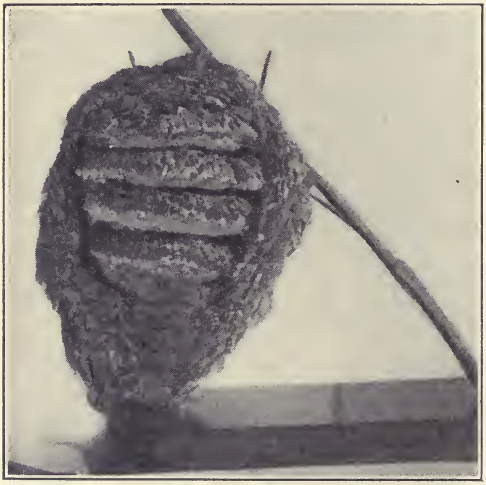


Fig. 39. Nest of hornet with part of covering removed.

Wasps have been called "the first paper makers." They secure materials from dried wood and work it over with their jaws, mixing with it a kind of liquid, and they finally mold it into cells and covering. These crude-paper nests are often found in trees and may be safely collected in the late fall, since most of the wasps die on the approach of cold weather.

The nests of the *mud dauber* are found in sheds, attics, and barns, attached to boards in various places. (Fig. 40) This wasp may often be seen around muddy places gathering material for her nest, which contains several cells about as big around as a pencil and an inch or two long. In each cell the wasp lays an egg and fills the cell with spiders, which serve as food for the larva that hatches from the egg. After filling the cell with food, the wasp caps over the cell with mud. When the young wasp inside becomes full grown, it gnaws off this cap and comes out.

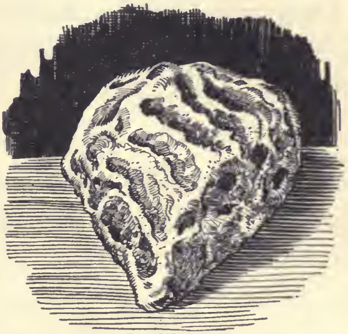


Fig. 40. Nest of mud-dauber wasp.

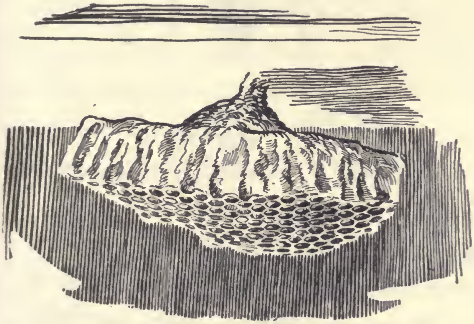


Fig. 41. Nest of *polistes*, one of the paper wasps.

Project 44 (G). Observing how the nest of the paper wasp and that of the mud dauber differ from each other.

1. Find a nest of the mud dauber, one of the hornet, and one of the *polistes* wasp. (Fig. 41) These nests may be safely taken after cold weather comes. With a pair of scissors carefully cut off one half of the covering of the hornets' nest. **2.** How do these three nests differ with respect to: (*a*) size, (*b*) the materials used, (*c*) shape, and (*d*) number of separate cells? **3.** How many thicknesses of paper are there in the covering of the hornet's nest? How many cell floors are there? About how many cells are there in a single floor? How many in all the floors taken together? What do you find in the cells of these nests?

ANTS

On the whole, perhaps the most interesting of these social insects are the ants (Fig. 42), because they do

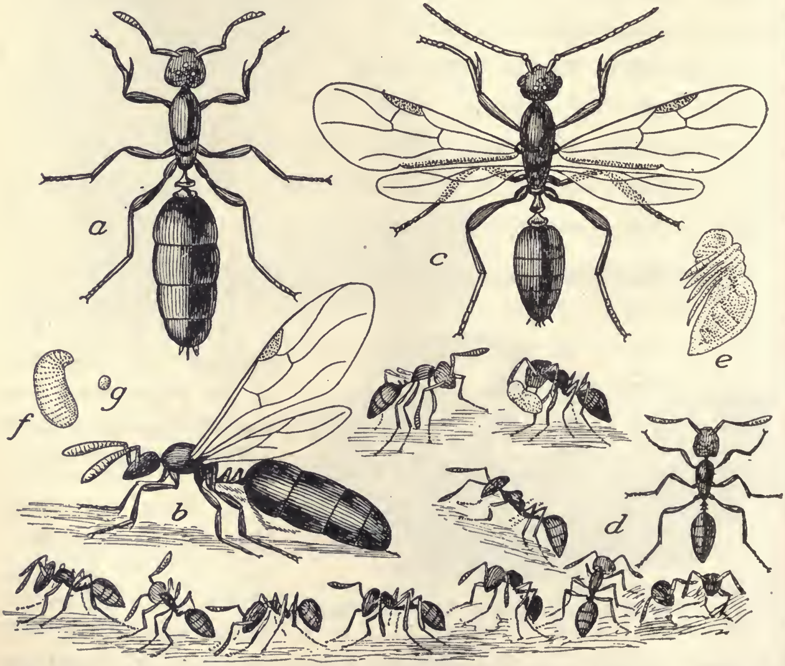


Fig. 42. Colony of ants: *a*, *d*, wingless females; *b*, winged female; *c*, winged male; *g*, egg; *f*, larva; *e*, pupa.

many things that suggest human activities. For example, ants keep slaves, make wars, keep cows, and farm.

How do ants fight? Keeping slaves and making wars are closely connected, because ants carry on wars to capture slaves. The ants from one colony start out in a long line and attack some neighboring colony. They fight with their jaws, trying to grasp other ants on the opposing side. If the attacking ants are victorious, they go into the homes of their enemies and capture the young found there, the larvæ and the pupæ. These they take back home, where they are fed and tended like their own young. When they develop into adults, they become a part of the family and help do the ordinary work of the colony.

How do ants keep cows? One of the most curious habits of ants is their method of keeping cows. Their cows are little insects called plant lice, which are found abundantly on all sorts of plants. The milk is a sweet fluid, called honeydew, that these plant lice give off. In the process of milking, the ant strokes the back of the plant louse with its feeler.

The ants give these lice a kind of care that corresponds to driving cows to pasture. The lice feed upon the sap of plants, which they suck with a long tube. When the supply of sap gives out, the ants sometimes take the lice and carry them to a new plant where there is plenty of food.

Furthermore, the ants do something that corresponds to raising calves. When cold weather comes in the fall, the ants take the eggs of the lice into their homes and keep them during the winter. When these hatch out in the spring, they are taken out and placed on some plant upon which the lice can feed. Sometimes the ants make cowsheds to protect the lice — little mud huts built around a group of lice on a twig on which they are feeding. (Fig. 43)

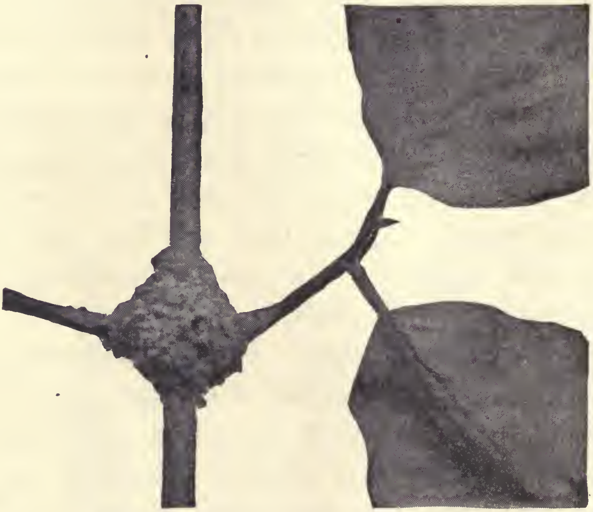


Fig. 43. A stable of mud for plant lice

Project 45 (I). Studying the habits of ants outdoors.

1. It is a common thing for ants to keep these cows. See whether you can find examples. Look carefully on all sorts of plants for plant lice. Watch them for a while to see whether any ants come near. If so, notice what they do. Whenever you see ants crawling up and down a plant, follow them to see where they go. Perhaps they are going to a "herd" of plant lice.

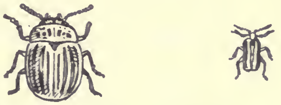
2. Turn over stones, boards, etc., to see whether you can find a colony of ants beneath. If so, notice what the ants do. What do you find in the nests? How is the nest made? **3.** Look for a little pile of sand that has been made by ants. How big is this pile? How many ants do you find around it?

D. Garden Insects

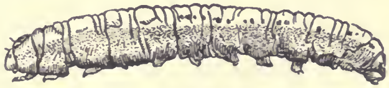
If you have ever had a garden, you must have often noticed insects around your plants. Some of these insects are your enemies and some are your friends. The harmful insects may feed upon any part of the plant, such as the stem, the leaves, or the root.

INSECT ENEMIES IN THE GARDEN

The *cutworm* is the caterpillar of a moth, which is so called because it cuts straight through the part of the plant upon which it feeds. (Fig. 44) It usually works close to the surface of the ground and may cut off small plants of a great many vegetables. In setting out plants, such as tomato plants, for example, one remedy is to wrap a heavy piece of paper around the stem or to put an old bottomless tomato can in the ground around it. Another remedy is to make a mash of bran, molasses,



Potato beetle Cucumber beetle



Cutworm

Fig. 44. Some enemies of the garden.

and Paris green. This is then scattered around the garden in small quantities. One should remember, however, that this is a very poisonous mixture to be used only with great care.

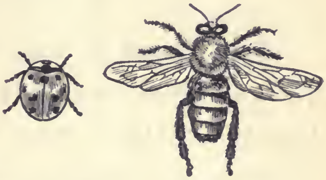
The *cabbage worm* is found on the cabbage plants. Eggs are laid on the plants by the white cabbage butterflies; these soon hatch into green caterpillars, which feed upon the plants. If one has only a small patch of cabbages, these caterpillars may be picked out by hand.

The *potato beetle* (Fig. 44) is an insect that is nearly always found in a garden where potatoes are raised. The eggs are laid in yellowish masses on the under side of the leaves. Soon they hatch into larvæ, which feed upon the leaves. The adults which appear later also harm the leaves. In a small garden patch these insects may be knocked off with a stick into a pan containing a little kerosene. Sometimes one may remove the leaves that have eggs on them if there are not too many.

The *cucumber beetle* (Fig. 44) is found not only on cucumbers but also on other creeping-vine crops, such as melons and squashes. Most of the harm is done when the plants are young. One very simple but effective remedy is to plant a large number of seeds — from fifteen to twenty — in each hill, so that there will be some plants left after they have been attacked by the insects. After the plants are large enough so that most of the danger from insects is passed, they are thinned out, leaving only three or four to a hill.

INSECT FRIENDS IN THE GARDEN

There are many helpful insects (Fig. 45) found in gardens, and it is well to know which these are so that we shall not hurt them. Bees, butterflies, and other insects seen around garden flowers, such as the blossoms of the pumpkin and squash, are good friends. They help to pollinate flowers. Were it not for the work of these insects, no pumpkins or squashes would be formed.



Lady beetle **Honey bee**

Fig. 45. Some insect friends of the garden.

Still other insects do good by destroying injurious insects. Among the helpful insects of this kind are the *lady beetles* (Fig. 45), the *ground beetles*, the *aphis lion*, and many others.

Project 46 (G). Studying the habits of some garden insects.

1. In order to study more closely the habits of garden insects, bring some into the schoolroom and keep them in an insect cage where they may be studied close at hand. Bring in some of the insects already mentioned, such as the potato beetle, the cabbage worm, the cutworm, or any others you can find in the garden. Each day fresh food of the plants upon which you find these insects feeding should be supplied in the breeding cage. **2.** Watch their feeding habits. How do they eat? What sort of mouth parts have they? Try different kinds of plants to see which they prefer. How much does an insect eat in one day in proportion to its size? **3.** Notice how different insects move about.

Study their organs of locomotion — their legs and wings. Note the different stages through which they pass as they grow up.

E. Household Insects

What harm is done by mosquitoes? Some insects, such as the fly and mosquito, are so common around the house that they may be called household pests; they are actually dangerous because they may carry disease. It has been known for some time that certain kinds of mosquitoes carry yellow fever and malaria. When a mosquito stings a person that is sick with one of these diseases, it sucks up some of the patient's blood, in which are myriads of the little organisms that cause the sickness. Then when this mosquito stings another person, it may leave some of these organisms in the wound; in this way the second person may be given the disease. In recent years such effective measures have been taken against the mosquito that yellow fever has been stamped

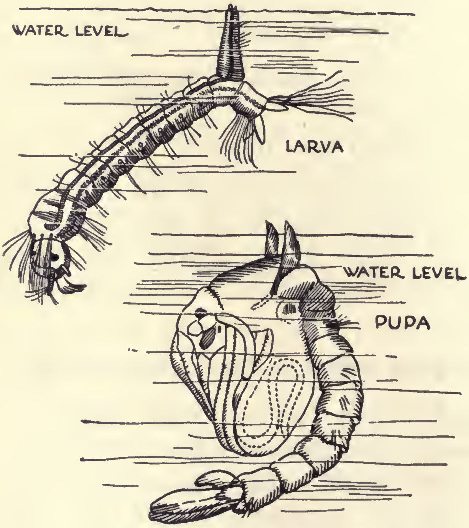


Fig. 46. Mosquito wigglers.

out almost entirely in the United States, and the number of cases of malaria has been greatly reduced.

How may the number of mosquitoes be lessened? One common means of controlling the mosquito is to screen the house to keep the mosquito out. Mosquitoes breed in water. Much can be done to kill the wigglers (mosquito larvæ and pupæ) (Fig. 46) before they reach the adult stage. Kerosene may be sprayed on the surface of the water, or fishes that feed upon wigglers may be placed in the ponds. Sometimes the marshes where the mosquitoes breed may be drained. Two common breeding places of mosquitoes are old tin cans and rain barrels that contain water. The tin cans should be buried or turned upside down. The rain barrels should be covered so as to prevent mosquitoes from laying eggs in them. (Fig. 47)

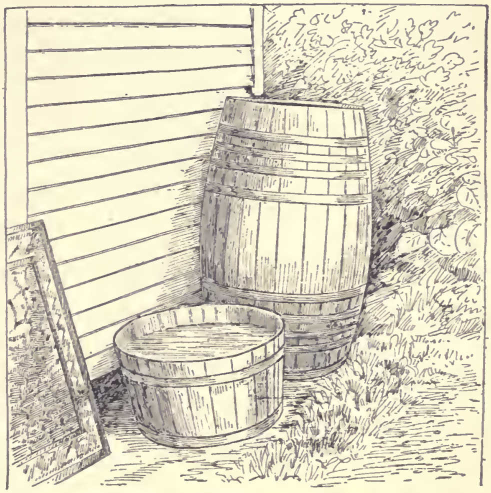


Fig. 47. Rain barrels, breeding-places for mosquitoes. Should be kept covered.

How is the house fly harmful? Another dangerous insect is the house fly. (Fig. 48) The way in which the fly carries disease is very different from the way in which the mosquito carries it. The fly feeds on all kinds of filth; little particles of filth stick to the hairs on its body and legs and to the hooks and sticky pads on its feet. Then it comes into our homes or into the baker's shop and alights on our food, leaving the filth there. In all filth are millions of germs, and in certain places, as in outdoor toilets, germs of disease are often found. When the flies carry these disease germs on to food, they are taken into the body of the person who eats the food, and sickness may result.

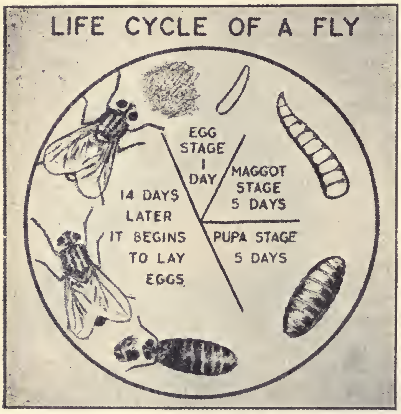


Fig. 48. Four stages of a fly: egg, maggot, pupa, adult.

How may we protect ourselves against the fly? Since most flies breed in manure, one way of lessening the number of flies is to take proper care of the manure. It may be hauled away every few days, it may be kept in a covered bin, or it may be treated with some chemical that will kill the larvæ and pupæ found there. We should also keep the house well screened and our food protected from flies. Fly traps may be set, and sticky papers used.

Project 47 (G). Observing the habits of mosquito wigglers.

1. Mosquito wigglers make interesting objects for study. Look in the rain barrels for them. Take them

out by means of a strainer, such as is used in the kitchen. Keep them in the schoolroom in ordinary tumblers or jars, covered with mosquito netting so that the adult mosquito cannot get out into the room. **2.** Notice the two kinds of wigglers, the larvæ and the pupæ. (Fig. 46) How do they differ in appearance? How do they move? What is their position when at rest? Find the breathing tubes by means of which they get air. Time one and see how long it stays away from the surface when disturbed. **3.** Notice the appearance of the adult mosquito. Find the feelers, mouth parts, and compound eyes on the head. How many wings are there? What is their appearance? How many legs has the mosquito?

CHAPTER IV

OTHER INTERESTING CREATURES

A. Spider Webs

What kinds of webs do spiders make? You are familiar with the regular mass of threads that make up the web of the cobweb spider so common in the house. Then, too, you have probably noticed on a dewy morning the many webs of the grass spider, which are simply floors on which the spider may chase and catch its insect prey, but which are not sticky and hence do not hold the insect.

The most interesting and remarkable of all, however, is the beautiful, symmetrical web made by the orb weavers. (Fig. 49) These spiders are common around all sorts of shrubs and other plants, in the garden, along roads, and in vacant lots. One admires the regularity with which the various threads are placed, one after the other, as though the distance had been measured. This web is composed of two kinds of threads, the spirals and the spokes. (Fig. 49) The spiral threads are sticky and elastic; by them the spider catches insects for its food. The spokes of the web are neither sticky nor elastic. They help to support the rest of the web and are paths on which the spider can walk without getting caught in its own web.

How do spiders build their webs? The spider makes its web new very often, sometimes as often as once every day. It usually begins its work about sunset. First, some irregular threads are fastened to the stems of plants or to other supports. Then the spokes of the web, or the *radii*, are spun across to make the foundation. Beginning at the center the spider next spins a rough spiral around and around as a staging upon which to work.

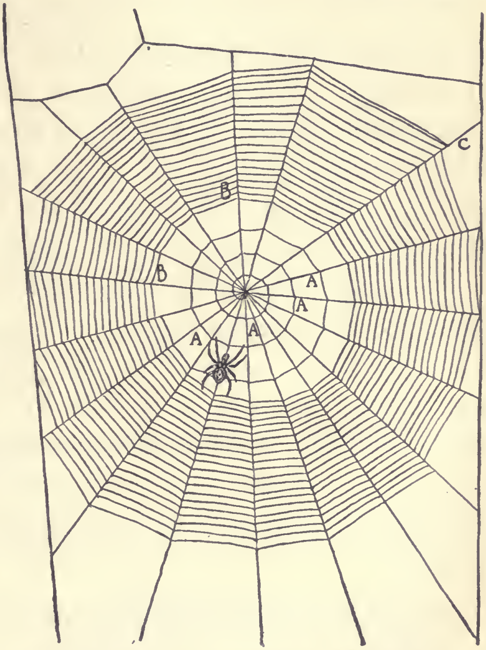


Fig. 49. Partially completed web of an orb weaver: *A*, first spiral, used as staging; *B*, second spiral; *C*, line running to shelter in which spider stays. From Davenport: *Zoology*.

Beginning now at the outside, the spider starts its final web of sticky threads. These are laid carefully and slowly. They are spun from tiny tubes at the tip of the body, known as *spinnerets*, and are so sticky that as soon as they touch the spokes they are held in place. After the spider goes around once, it continues the spiral just inside the first coil like the spring of a clock.

In order to get the proper distance from the first coil the spider backs down the radius, reaching for it with one leg until the first coil is touched; then it turns its body around and fastens the next spiral at the point just opposite the spinnerets, one pair of legs being used almost like a pair of hands to play out the silk as fast as it is spun. When it comes to the staging which was first made, it cuts off a piece of the thread with its jaws and allows it to drop out of the way. Thus the spider spins around and around until the web is finished. The process usually takes several hours.

Sometimes the spider makes a little shelter at the edge of the web by fastening leaves together, where it waits for insects to be caught in the web. From the web to the shelter extends a thread by means of which the spider can tell, by the feeling, when something has been caught. It then runs out and further entangles the insect by wrapping it up in a broad ribbon of silk which it spins.

Project 48 (I–G). Studying the orb weaver's web.

1. Make a drawing of a web in your science notebook. 2. Place the end of your pencil on the spiral and then on one of the spokes and notice how the two threads differ. 3. About how many times does the spiral go around the web? About how far apart are the coils? 4. Where does the spider stay? What is its appearance in regard to color, shape, and size? How many legs has it? How many parts are there to the body? 5. Throw an insect into the web and notice what the spider does. 6. About sunset or a little later find a spider spinning its web and watch to see what it does.

B. The Earthworm

Is the earthworm a beneficial or harmful creature? You know that it makes good bait for fishing; for that reason it is often called "angleworm." It is also very helpful in improving the soil.

In order to get food, the worm takes soil into its body and, after removing the decaying matter for its food, throws out the remainder as castings, which you have doubtless seen on the surface of the ground. In this way the soil from below is worked over and brought to the surface and, as a result, made better for the roots of plants to grow in. There are so many earthworms working constantly that the effect of all combined in improving the soil is very great.

Project 49 (G). Making a cage in which an earthworm may be kept indoors. (Fig. 50)

1. Secure a small, uncovered, wooden box about a foot wide, eight inches deep, and of any length in which it may happen to come. **2.** Secure a pane of glass of just the right size to slip easily into the box and make a partition across one end of the box. Nail two strips of wood on the inside of the box, one on each side, and near enough to the end, so that when the pane of glass is slipped inside of them

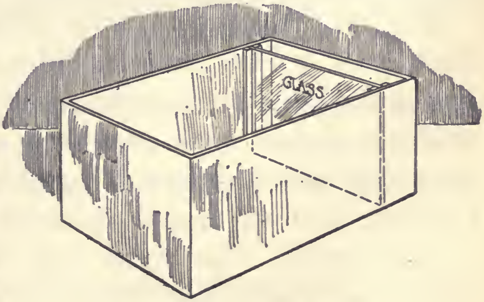


Fig. 50. Box for earthworm.

there will be a space of about one-half inch between the glass and the end of the box. (Fig. 50) Fill this space with fine garden soil to within about an inch of the top. **3.** Now place a large earthworm on this soil. Put a piece of cardboard against the glass to keep the chamber dark. Occasionally remove the cardboard and see what the earthworm is doing. Let it stand overnight and look at it the next morning. If the box is not very long, you may wish to cut out the end opposite the glass, so that you can watch the earthworm more easily.

C. Bird Nests

Bird nests may be easily seen after the leaves fall and they may be collected then without harming the birds, who have finished using the nests for the year and seldom use the same nest a second time.

Bird nests are often called bird homes, but a better name would be bird nurseries because they are used only to raise the young birds and are then abandoned.

How do the nests of birds differ from one another? Each kind of bird builds a different kind of nest, and it is possible for one who knows birds to tell which bird made a certain nest just from seeing it. (Fig. 51) Although many different materials are used in nest building, you will find that the most common material is dried grass. The robin uses mud, the house wren sticks, and the crested flycatcher a cast-off snake skin. Usually the inside of the nest is made of finer material than the outside. Sometimes horsehair is used for a lining. The chipping sparrow often makes its nest almost entirely of horsehair.

Nests are found on the ground, in trees, in shrubs, in banks, and upon buildings. The bank swallow makes its nest in a tunnel in a bank; the chimney swallow builds in chimneys; the Baltimore oriole suspends its nest from a branch of a tree; and other birds, such as wrens, bluebirds, and martins, nest in houses provided by man.

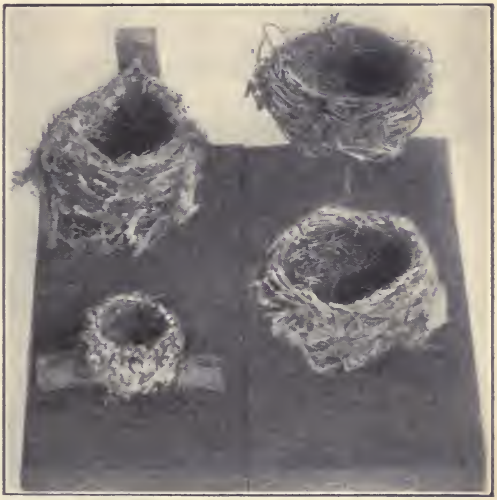


Fig. 51. A group of nests.

Among the nests that may be mentioned on account of the care with which they are made are those of the humming bird and the Baltimore oriole. Among the crudest nests are those of the cuckoo and the mourning dove, which consist of irregular masses of small sticks loosely put together, with only small depressions for the eggs.

Project 50 (G). **Making a collection of nests for the school museum.**

1. Collect as many different kinds of nests as possible. **2.** In order to keep and handle the nests you will need to mount them in some way. One simple way is to place each nest in a pasteboard box of about the right size. (Fig. 52)

3. If you wish, you can mount them in the way that is used in regular museums. From an ordinary board cut pieces about three by four inches. By means of a gimlet bore a small hole in the center. Procure four or five pieces of medium sized iron wire, each about nine or ten inches long. Put them together in a bundle and twist them for about four inches of their length. Press the twisted ends firmly into the hole in the wood. Spread the other ends of the wires until they are horizontal. On these place the nest and then bend up the wires around and inside the nest so as to hold it securely. (Fig. 52)

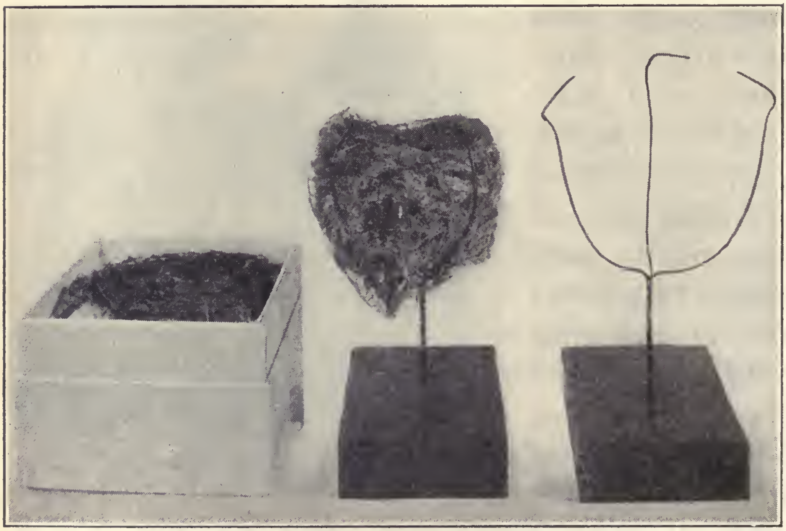


Fig. 52. Two methods of mounting nests.

4. Label the nests with the name of the donor and that of the bird, if you can find out what bird made it.

Project 51 (G). Observing the kinds of materials of which birds' nests are made.

1. Make a list of the materials you find in each nest. What difference do you find between the materials used for the inside and the outside. **2.** After finishing the study of all the nests, determine which is the most common material used. Which is the least common? Do you find any materials that you might put out in the spring to help the birds make their nests? **3.** Which is the largest nest? Which is the smallest? Which is the best made nest? Which is the most poorly made?

Project 52 (G). Making a nest census of your city.

1. In the late autumn after the leaves have fallen you can make a nest census of a part of your city. First a map should be made of the streets of some part of the city that is well supplied with trees. These streets should be divided among the children to visit and report on. **2.** Look carefully at all the trees and make a record of all the nests you find. When you return to the schoolroom, put down a dot on your part of the map for each nest you found. **3.** If possible, find out how many people living along these streets had bluebirds, wrens, or other birds nesting in bird houses. **4.** After all have reported, copy the map in your notebook.

CHAPTER V

THE SCHOOL AQUARIUM

An aquarium may serve two uses in a schoolroom: first, it is a means of ornamentation, like a house plant; and second, you may derive much pleasure from watching the life that is kept there. A battery jar holding a gallon makes a very satisfactory aquarium. Other glass containers may also be secured. (Fig. 53)

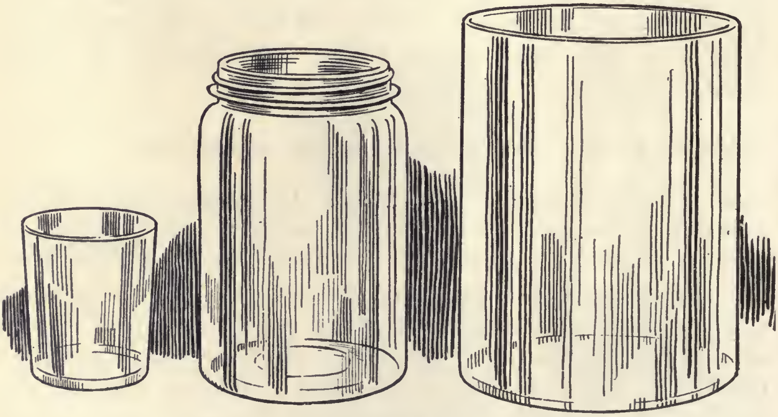
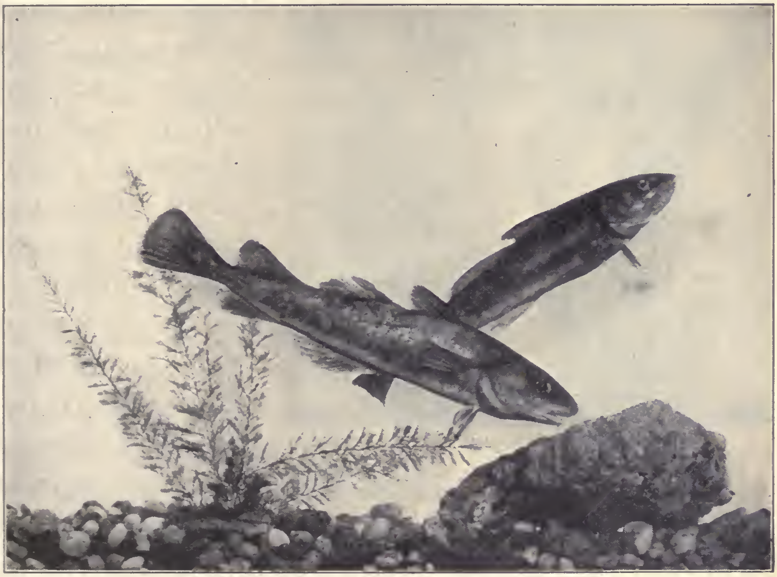


Fig. 53. Some simple aquarium jars.

What plants may be kept in an aquarium? In order to have an aquarium that may be kept for a long time, both plants and animals should be put into it. (Fig. 54) The plants furnish *oxygen* for the animals, and the animals furnish *carbon dioxide* for the plants. Thus they may live a long time together without having the water changed. Plants found growing in ponds may be used. Among the best are eelgrass, stonewort, hornwort, water milfoil, and pondweed. (Fig. 55) The bottom of the aquarium should be covered with half an inch of clean sand or pebbles, and the roots of the plants should be anchored there.

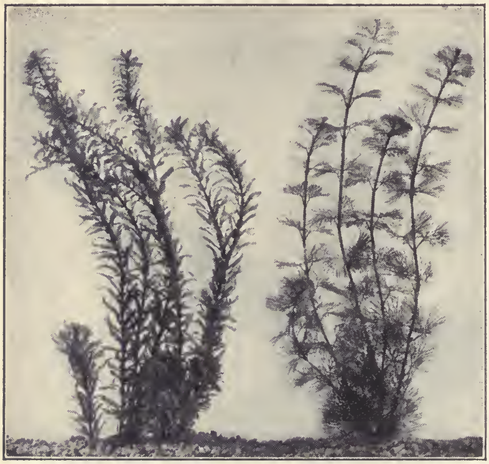


Courtesy The New York Zoological Society

Fig. 54. Balanced aquarium with both plants and fishes. From Peabody and Hunt: *Biology and Human Welfare.*

What creatures can be kept in an aquarium? Fishes, water insects, snails, and tadpoles can be kept in the aquarium. Snails and tadpoles (Fig. 56) are called scavengers because they help to keep the sides of the glass clean by feeding on the green coating that sometimes forms there. Care must be taken not to put too many animals in one aquarium. Each gallon of water will support one fish three inches long, one snail, one tadpole, and several water insects. The activities of these various animals — how they swim, eat, and breathe — will furnish interesting subjects for study.

The aquarium should not be kept in a sunny place, except for an hour or two a day. Screens may be placed behind the aquarium to protect it from the sun's rays, if the sun should naturally fall on it for longer than this period.

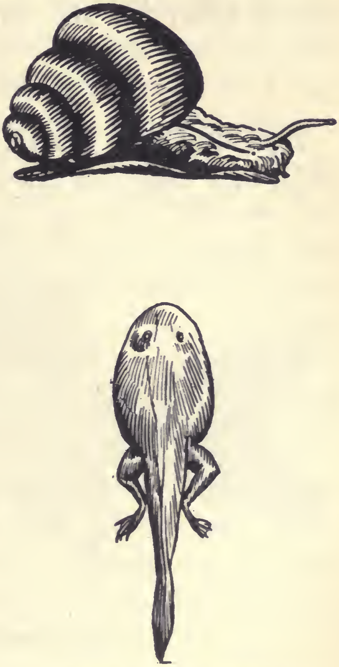


Courtesy The New York Zoological Society

Fig. 55. Some aquarium plants. Elodea plants at left, cabomba leaves at the right. From Peabody and Hunt: *Biology and Human Welfare.*

How should the creatures be fed? For fishes the specially prepared fish food may be used. The common mistake is to feed the fishes too much. Any food that is not eaten decays and makes the water dirty. For a fish three inches long a piece of fish food from a quarter to a half inch square once a day is sufficient. In the schoolroom an extra piece may be fed Friday afternoon to last until Monday morning. The snails and tadpoles do not need to be fed; they find their own food in the aquarium. To feed the water insects, once a week tie a bit of raw meat to a piece of string and allow it to stay in the water about an hour.

How often should the water be changed? Many people have the mistaken notion that the water in the aquarium must be changed every few days. If there are no plants, this change must be made to furnish oxygen. But in the aquarium such as we have in mind the plants furnish oxygen for the animals, the animals carbon dioxide for the plants, and the water does not need to be changed at all. Once or twice a year it may be well to clean the whole aquarium, and at that time fresh water may be used to replace the old. Otherwise add a little water once a week to take the place of that which has evaporated.



Snail (above) and tadpole

Fig. 56. Scavengers of the aquarium.

Thus you see that very little care is required to keep an aquarium: 1. Once a day feed the fishes. 2. Once a week add a little water.

In order to handle the fishes and other animals, a small net will be convenient. You can make one just as you made the insect net (page 49), except that it would be better to use a small wire and short handle, and to make the net only three or four inches wide.

A. Fishes

How do fishes swim? Fishes swim by means of fins. (Fig. 57) Some of these are arranged in pairs, one on each side of the body, and others are unpaired, arranged along the middle. The chief propelling organ is the tail fin, which is also used as a rudder in steering. While the other fins may help to some extent in propelling, their chief use is to balance and direct the body. These motions of the fins may easily be studied by watching a fish in an aquarium.

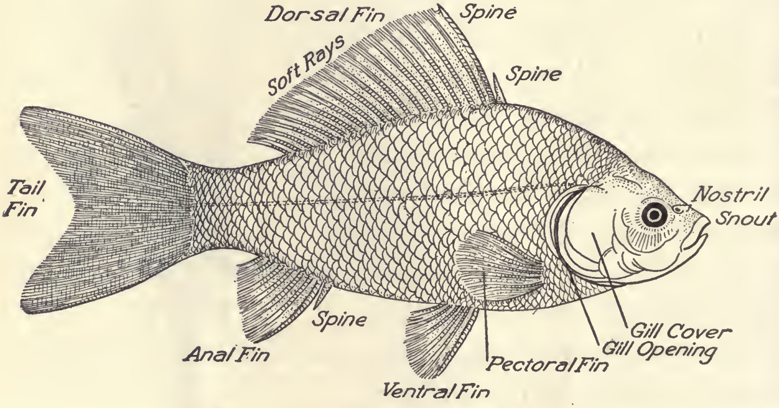

Dorsal Fin
Spine
Soft Rays
Spine
Tail Fin
Nostril
Snout
Spine
Anal Fin
Ventral Fin
Pectoral Fin
Gill Cover
Gill Opening

Fig. 57. Goldfish, with parts named.

How do fishes breathe? Animals that live in water must have air to breathe just as much as animals that live on land. A certain amount of air is mixed with water, and fishes have a means of obtaining this air through an organ called a *gill.* These gills are thin, membranous structures situated on each side of the head. They are usually protected by a gill cover which has an opening or cleft to the outside just back of the gills. In the process of breathing, the water is taken in through the mouth and forced over the gills and out through the cleft, as may easily be observed in the living fish. Many blood vessels extend through the gills; and as the blood passes through them, it takes air from the water and is purified.

What do fishes eat? In the upper layers of ponds, lakes, and oceans are countless numbers of small plants and animals, including many microscopic forms and many small creatures known as *crustaceans.* These forms are one important source of food for fishes. Many fishes feed on other fishes; some feed on mollusks and crustaceans found on the bottom of the ocean; some fresh-water fishes feed on insects.

Project 53 (G). Observing the habits of the fishes kept in the aquarium.

1. *Swimming.* Watch carefully the swimming habits of some one fish. How many fins has it? On what parts of the body are they placed? How do they differ from each other? Which ones does the fish use most in swimming? Compare its method of swimming backward with that of swimming forward. When the fish is at rest, does it move its fins? How does the fish steer itself?

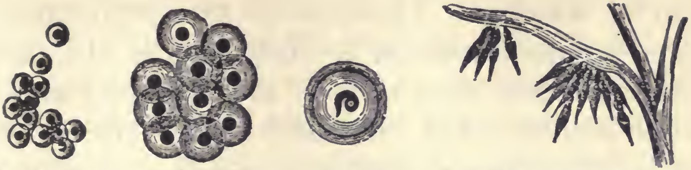
2. *Eating.* Notice how the fish eats. Does it have any teeth? See whether you can tame it so that it will come to the surface and take food from your hand.

3. *Breathing.* Watch the motion of the mouth and the gill covering to see how the fish breathes. Do these motions occur regularly? How many in a minute? How many times do you breathe in a minute?

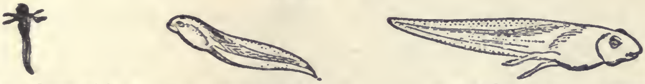
B. TADPOLES

Tadpoles are young frogs and toads. Eggs are laid in the water during the spring by the mother frogs and toads. The eggs of the toad are laid in long strings, while those of the frog are laid in large masses. In the early spring the toads migrate to the ponds, where the eggs are laid. During this season the rather musical trill of its song may be heard. While giving this note the throat is swollen out like a bagpipe. The eggs are laid on the bottom of the pond or on water plants in a long string, resembling a necklace, composed of transparent jellylike substance with the eggs scattered through it as little black dots. From five to ten thousand eggs may be laid at one time.

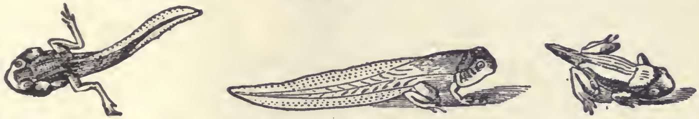
These eggs soon hatch into tiny tadpoles, which go through a series of rapid changes. (Fig. 58) At first the tadpole is provided with external gills on the side of the head, but later these disappear. After a few days a mouth appears; in about a month the hind legs begin to show; then the fore legs; the tail shortens; and at the end of six to eight weeks there comes out of the water a small but well-developed toad.



A, eggs before they are laid *B*, eggs after they are laid *C*, egg containing young tadpole *D*, young tadpoles attaching themselves to a plant



E, young tadpole with external gills *F*, young tadpole with internal gills *G*, young tadpole with hind legs



H, tadpole with webbed feet *I*, tadpole with legs and arms *J*, young frog

Fig. 58. Life history of frog. From Peabody and Hunt: *Biology and Human Welfare*.

Project 54 (G). **Noticing the difference between the habits of the snail and the tadpole.**

1. *Locomotion.* How do these two animals differ in regard to (1) their method of locomotion, (2) the rapidity with which they move? What part of the body is used in each case? Does either one ever come to the surface? What is the position when at rest? Where do they stay most of the time? Can the snail move when out of the water? Can the tadpole?
2. *Eating.* Watch both to see how they eat and what they eat.

C. Water Insects

What interesting habits have water insects? (Fig. 59) Water insects may easily be caught in nets and kept alive in glass jars in the schoolroom, where their habits may be watched. These insects may be divided into three groups according to their habits. In the first group are those that stay on the surface, such as the water strider and the whirligig beetle. In the second

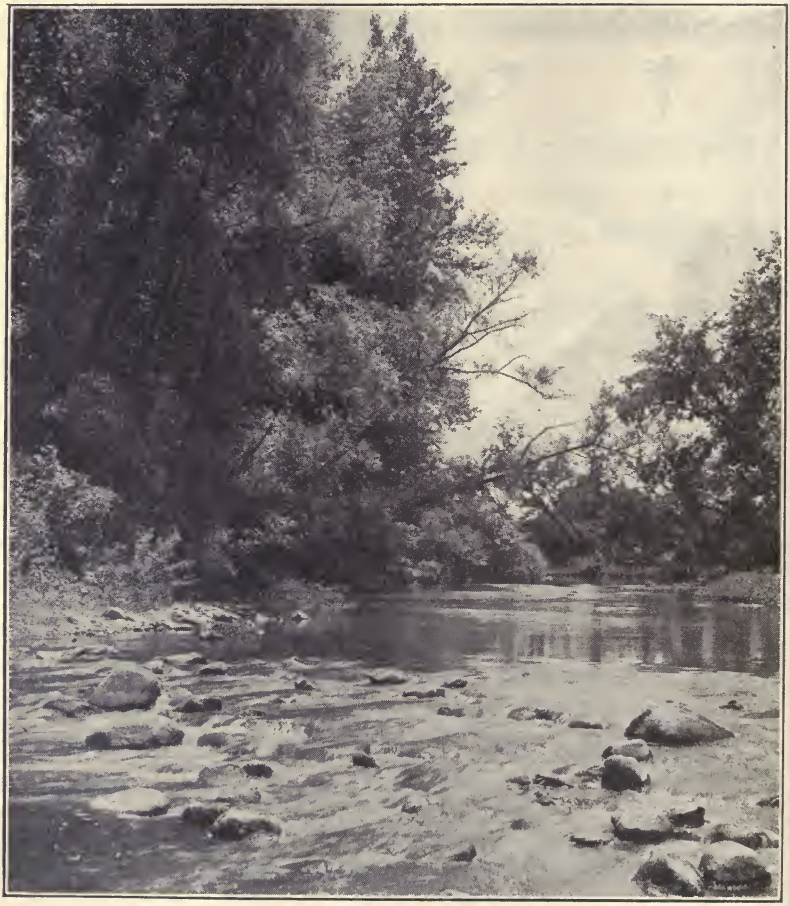


Photo from Ewing Galloway, N. Y. © J. C. Allen

Fig. 59. At the brook. Many interesting creatures may be found in a brook.

group are those that have the body submerged in the water, but with a tip of the body extending to the surface to get air when at rest, such as mosquito wigglers, water boatmen, back swimmers, water scorpions, and diving beetles. When not taking air, these insects are very active and may be found swimming in any part of the water. To the third group belong those insects that have gills for breathing and hence do not need to come to the surface for air.

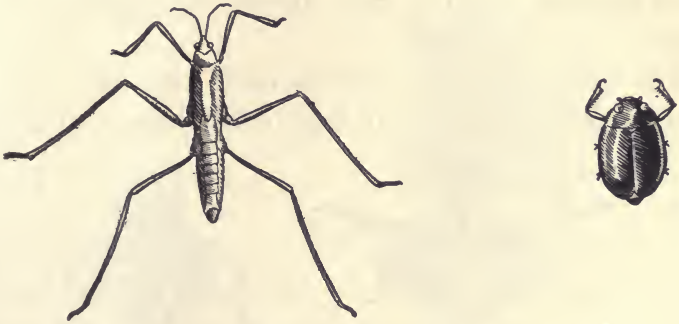


Fig. 60. Insects that live on the surface of the water. The water strider and the whirligig beetle.

The most curious feature about the water strider and the whirligig beetle (Fig. 60) is their method of walking on top of the water. They can walk in this way for the same reason that a needle can be made to float on water although it is much heavier than water. The surface of any body of water acts as a thin membrane of rubber stretched across it, and small objects that are heavier than water are held up by *surface tension*, as it is called. (Project 95, page 183)

Another curious feature about the whirligig beetle is its eye. When the beetle is resting on the water, the water line passes across the eye dividing it into two parts, an upper part adapted for looking up into the air and a lower part for looking down into the water. Still another interesting feature of this beetle is the little ball of air which it takes on the tip of its body to enable it to breathe when it goes below the surface of the water.

The water boatman and the back swimmer (Fig. 61) both have the hind pair of legs broad, long, and oarlike, adapted for swimming. The back swimmers have backs shaped like the bottom of a boat and they swim on their backs. The water boatmen are flat and when near the bottom of the pond, breathe the air that encases their bodies like a silver coating.

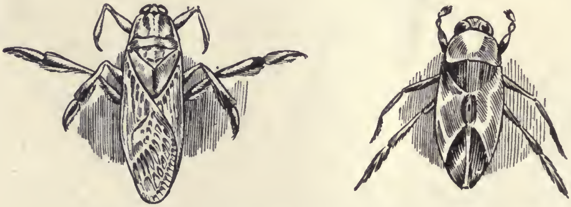


Fig. 61. Insects that live in the water.

The interesting feature of the *caddis* or *case* worm is the beautiful little case which it builds and lives in while in the water. (Fig. 62) These cases are about an inch long and as big around as a lead pencil. Some of them are made of little bits of sand cemented together and lined with a soft silk thread which the worm spins.

When it gets through the worm stage, it changes into a fly that lives in the air and looks much like a moth.

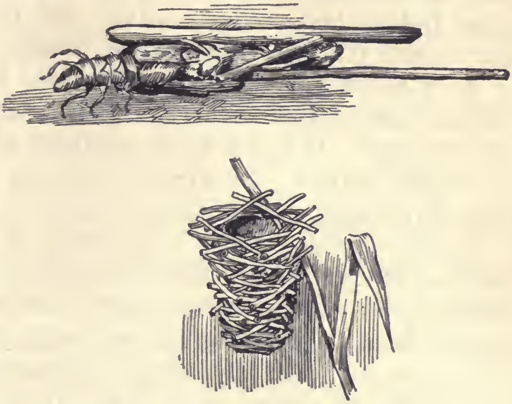


Fig. 62. Cases of caddis worm.

Probably you have seen the large active dragon fly, or darning needle, flying over ponds. The young dragon fly, called a *nymph*, is a very different appearing insect, looking something like a grasshopper. (Fig. 63) It lives on the bottom of the ponds, catching such insects as mosquito wigglers with its large jaw. It moves slowly about by crawling on the bottom of the pond and it can also swim through the water by forcing water backward from a hole in its body, thus driving its body in the opposite direction.

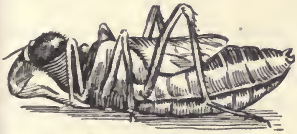


Fig. 63. Nymph of dragon fly.

Project 55 (G). **Watching the habits of those water insects that may be kept in an aquarium.**

1. *Water striders and whirligig beetles.* How does each move? What part of the body touches the water? To explain how these insects are able to stay on the water, try to float a needle on water. (Project 95, page 183) Place the dish in the sunlight and notice the

shadow made by the water strider. Do these insects ever leave the surface of the water? What is the position of these insects when at rest? When the beetle goes below the water, notice the tip of its abdomen. How does it swim when below water?

2. *The back swimmer and water boatman.* How do these two differ in appearance and position when swimming? What is their position when at rest? How do they swim? In what ways are their legs adapted to swimming? How do they get air to breathe?

3. *The caddis worm.* In order to keep these insects permanently, either the aquarium must be provided with plants or the water must be changed every two or three days. However, they may be kept for a few days in a jar filled with water changed every day or two, and then returned to a pond after you have studied their habits. Notice the shape, color, and size of the case. Of what materials is it made? How does the animal move?

4. *The nymph of dragon fly.* These insects, like the previous ones, take air from the water, hence the water must be changed or plants provided. How does the animal move? Can it move either forwards or backwards? To learn another way in which it moves, take it from the aquarium and place it in another dish of water. Now place a drop of red ink near the tip of the abdomen. Can you explain what happens? Now place it back in the aquarium. Notice the large jaw under the head. Notice how it is used in securing food. To provide food place some mosquito wigglers in the aquarium. When not in use, where is the jaw carried?

CHAPTER VI

ROCKS AND MINERALS

A. Rocks

As you look over the surface of the earth, you see plants growing almost everywhere. Underneath these plants is the soil in which the roots live. Still farther below the soil, if one digs down far enough, one always comes to solid rock. Sometimes this soil covering may be several hundred feet thick and sometimes only a few inches. In still other cases the solid rock comes clear up to the surface of the earth. The covering of soil is very thin anywhere as compared with the thickness of the solid rock beneath.

In what ways are rocks useful? Rocks are very useful to man. In the first place all soil was made from rock, and soil is necessary for plant life. So we are dependent on rocks for all the things we get from plants, such as food and clothing.

Some rocks are useful also as building stones, for making either the foundations of buildings or their entire walls. Other rocks are used for making valuable monuments, and still others are used for ornamentation in putting up fine buildings, such as marble for floors or pillars. Scientists have found that all rocks can be grouped into three kinds according to the way in which they have been made. One group is called *sedimentary* rocks, because they have been formed from sediments, that is, small pieces of rocks. Since most of these were formed in water, we may also call them water-formed rocks. Water has the power of sorting materials according to their size. Hence these *water-formed* rocks are usually arranged in layers and are said to be *stratified*. This sorting power of water may be easily shown by the following simple experiment:

Project 56 (G). Showing the sorting power of water.

1. Put about an inch of ordinary soil in a canning jar. Fill it about half full of water. Cover the mouth of the jar and shake vigorously. Then set the bottle on the desk. **2.** Notice which particles settle first. After the bottle has stood for a day, notice how the materials are arranged. Does this differ from the way they were arranged in the soil you first put in the bottle?

What are some of the common kinds of rocks? Among the more common rocks in the water-formed class are *sandstone* and *limestone*. Sandstone is made up of small bits of a mineral known as quartz, of a grayish or brownish color. These bits were brought down by rivers and deposited in the ocean, just as other sediments are now being left at the mouths of rivers; later they were so bound together by some kind of chemical that they became solid rock.

Limestones were formed from the skeletons of water animals that lived many, many years ago: corals, shell fish similar to clams and oysters, and still smaller animals. Common chalk is a form of limestone that was made from the shells of tiny creatures that lived in the ocean thousands of years ago. When the creatures died, their shells dropped to the bottom of the ocean, where they formed chalk.

Among the water-formed rocks are found many remains, known as fossils, of both plants and animals that lived many years ago. Sometimes the shells or bones of the animals are found, and again the forms of beautiful fernlike plants, imbedded in the rocks. From these fossils we can get some idea of the kinds of plants and animals that formerly lived on the earth.

A second group of rocks is called *igneous rocks*. "Igneous" comes from a Latin word meaning *fire*. The first form of these rocks was a hot liquid. As they became cooler, they changed to solid form. Doubtless you have read about volcanoes and you learned that when the molten materials are first thrown out, they run down hill just like water, then quickly cool and become solid. One common kind of igneous rock is granite, often made into beautiful monuments. Granite is made up of several minerals such as quartz and mica.

The third class of rocks is called *metamorphic rocks*. This long word means *changing from one form to another*. Such rocks have been made from rocks of the other two classes. For example, granite may be changed into a rock known as gneiss, and limestone may be changed into marble. These changes are brought about by heat, water, and pressure. One of the most valuable rocks in this group is marble, with its great variety of colors — white, black, red, pink, and green. Marble takes a beautiful polish and so it is used for building stone, monuments, and ornamentation.

Project 57 (G). Making a collection of rocks.

1. You will need a heavy hammer to break off pieces of rocks and to open large pebbles. For the collection you should get pieces of rocks about as big as your fist. A small bottle of muriatic acid, which you can get at a drug store, will help you tell the limestones and marbles. Handle the acid carefully, for it will burn skin, flesh, or clothing readily. When a drop of acid is placed on these rocks, a bubbling occurs. This is due to the fact that a gas is given off, called carbon dioxide, which is the same gas as that used to make soda water. **2.** Visit: (1) any exposed rock surface, (2) quarries, (3) rivers' banks, (4) road cuts, or places where the soil or solid rock is exposed, (5) boulders and loose stones on the surface of fields and pastures, (6) monument stores. In road cuts and along streams look for large pebbles or small rocks. Break these open with your hammer so as to get a fresh exposure. Places where there is a deep cut in the soil may furnish you many kinds of rocks because most of the soil in the northern part of the United States has been brought by glaciers from regions many miles farther north. In monument stores you may often get specimens of granite and marble. **3.** For each specimen provide a small card on which should be written the name of the rock and the locality where it was found.

4. After you have a good collection, make a study of the specimens to see how they differ: (1) in color,

(2) in the minerals of which they are made, (3) in the way in which the materials are arranged, and (4) in the action of acid on them. **5.** Arrange your collection in three groups: (1) the sedimentary rocks, (2) the igneous rocks, and (3) the metamorphic rocks.

B. MINERALS

One of the interesting things about minerals is that many of them exist in the form of beautiful crystals. These vary greatly in shape according to the mineral; some are cubes, some prisms, and some pyramids. (Fig. 64)

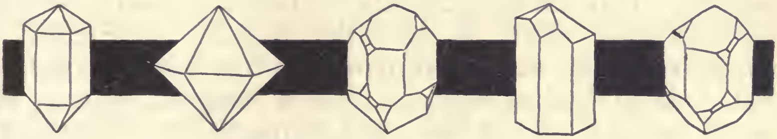


Fig. 64. Forms of quartz crystals.

Project 58 (G). Studying the formation of crystals.

1. If you dissolve certain substances in water and then let the water evaporate, crystals will be formed. **2.** Secure from home a common sauce dish, a cup, a teaspoon, and some salt. Fill the cup about a third full of water. Then add salt and stir with the teaspoon till no more will dissolve — that is, till some salt is left in the bottom of the cup. Then pour off the clear liquid into a sauce dish. In this liquid put a piece of string and a narrow strip of colored paper. Place the dish on the window sill and allow it to stay there till the water evaporates. Examine the crystals that are left. What is their shape? Look at them with a reading glass. **3.** For another experiment get a small piece of board, such as the cover of a chalk box.

Mix a salt solution as directed in the previous experiment and then pour enough on to the board to cover a space an inch or two across. Allow it to stand till the water evaporates.

4. As another experiment at home, use boiling hot water and follow the directions already given in paragraph 2. What difference in the results do you notice from those obtained when cold water was used? **5.** Another substance that you may use in place of salt is lump alum. If you wish to secure some beautifully colored blue and red crystals, use some blue vitriol and bichromate of potash. Do the experiments as already described for salt. Since these substances are both poisonous, you must be careful not put any in your mouth. How do the crystals of these substances differ from those of salt? **6.** In order to make rock candy, dissolve all the sugar you can in a test tube or bottle half full of boiling water. Tie a weight, such as a small iron nut or a pebble, to a string. Put this string in the solution in such a way that the weight nearly touches the bottom of the tube and tie the other end of the string to a match placed across the top of the tube or bottle. Allow it to stand till the water cools. Notice what forms on the string.

How do minerals differ in hardness? Not only do minerals differ in their shape, but also in their color and hardness. By hardness is meant the ease or difficulty with which they may be scratched. We have a scale consisting of ten grades of minerals, numbered from one, which is the softest, to ten, which is the hardest. Numbers *one* and *two* are so soft that they may be scratched with the finger nail; numbers *three* and *four* can be scratched with a knife blade, and *five* and *six* with glass. Those above *six* are very hard, the diamond, number *ten*, being the hardest of all.

Of what use are minerals? Minerals are of use in a number of ways. The minerals known as ores are the source of many valuable metals such as iron, copper, lead, and tin, besides gold and silver. And finally some minerals are so valuable for adornment that they are called gems and precious stones. Among these are diamonds, rubies, sapphires, emeralds, garnets, and opals.

What are some common minerals? *Quartz* is the most common of all minerals. When formed as pure crystals, it occurs in the form of six-sided prisms capped with six-sided pyramids. (Fig. 64) Quartz may be as clear as glass, but more often it is colored white, yellow, violet, red, or green. *Flint* is a form of quartz. Before the invention of matches, flint, on account of its hardness, was used to strike a spark to set fire to tinder and gunpowder. The Indians made hatchets and arrow tips from flint. The petrified trees found in the western United States are forms of quartz. The quartz has so exactly replaced the wood that the structure of the trunks of these trees can still be seen.

Calcite is another common mineral. (Fig. 65) While it looks something like quartz, it is easily told from quartz in two ways: first, it is much softer than quartz; its hardness is only 3, while that of quartz is 7; that is, calcite can be scratched with a knife while quartz cannot. Second, if a drop of acid is put on calcite, it bubbles the same as limestone and marble.

Another common mineral is *mica,* often called *isinglass.* It splits easily into broad, thin sheets. Since it can stand great heat, it is sometimes used in stove doors. It is used by electricians because electricity does not pass through it. Shining particles of this mica are often seen at the seashore mixed with sand.

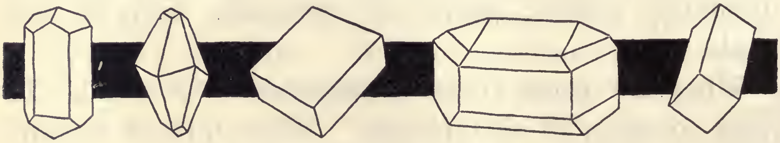


Fig. 65. Forms of Calcite Crystals.

Project 59 (G). Making a collection of minerals.

1. Some parts of the country have a much larger variety of minerals than do other parts. But no matter where you live, you can find some minerals, for stones and rocks contain minerals. **2.** Visit quarries and rock exposures anywhere; look in any cavities that you can find in the rocks. Visit any place where large pebbles may be found, such as river banks and road cuts. Break open the pebbles with a hammer. You will sometimes find beautiful crystals within. **3.** Keep the specimens in the same way suggested for rocks, Project 57, paragraph 3. **4.** Arrange your minerals in order according to hardness, from the softest to the hardest. If you are in doubt as to which is the harder of two minerals, try scratching one with the other; of course the harder will scratch the softer. **5.** Put a drop of acid on each specimen and see which ones bubble. **6.** How do the minerals differ in their color and the shape of their crystals?

CHAPTER VII

PLAYGROUND SPORTS

A. The Seesaw

Of what use are levers? The *seesaw* or *teeter* (Fig. 66) is an example of a *lever*. The fixed point at which the lever balances is the *fulcrum*, and the two ends are the *arms*. The lever has many uses in everyday life. One use, as in the case of the crowbar, is for lifting heavy weights. If the fulcrum is placed very much nearer one end than the other, a small force at

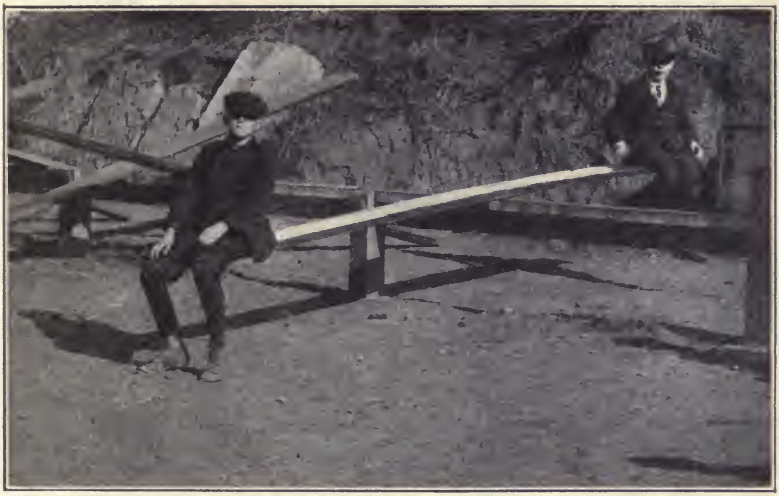


Fig. 66. A seesaw or teeter is a kind of lever.

the end of the longer arm can lift a very heavy weight at the end of the shorter arm. For example, we will suppose that a boy who can lift one hundred pounds wishes to move a stone weighing five hundred pounds. If the balance point, or *fulcrum*, of the crowbar is placed in such a position that the crowbar is five times as long on the side of the fulcrum from the stone as it is on the other side of the fulcrum near the stone, then the boy can move the stone by exerting a pressure of one hundred pounds at the end farthest from the five hundred pound weight.

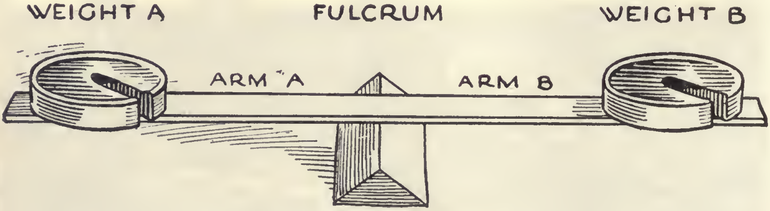


Fig. 67. The law of levers. Wt. $A \times$ arm A = Wt. $B \times$ arm B.

There is a definite relation existing between the two weights and the distances of the weights from the center. This law of the lever is stated as follows: The weight on arm *A* (say, in pounds) multiplied by the length of arm *A* (say, in feet) equals the weight on arm *B* multiplied by the length of arm *B*. (Fig. 67)

Other examples of the lever besides the *seesaw* are the wheelbarrow, hammer, scissors, pliers, and nutcracker. (Fig. 68) Make a list on the board of all the different kinds of levers that you can find during a week.

Make drawings of some of them in your science notebook. Label the fulcrum in each case.

Project 60 (G). Discovering where two children must sit on one end of a teeter in order to balance one child on the other end.

1. Read about *group* work in *To the Boys and Girls.* **2.** To perform this experiment you will need a yardstick, a triangular block of wood, and a number of objects, each weighing about the same, such as several copies of the same book. **3.** Place the yardstick at its middle point on the edge of a triangular block. If it does not balance, fasten some object, such as paper or wire, on one arm until it does balance. **4.** Place one book on the stick so that its middle point is six inches from the center. Place another book of the same size and weight on the other side of the stick and move it back and forth until the stick balances. How far is the middle point of this book from the middle point of the stick?

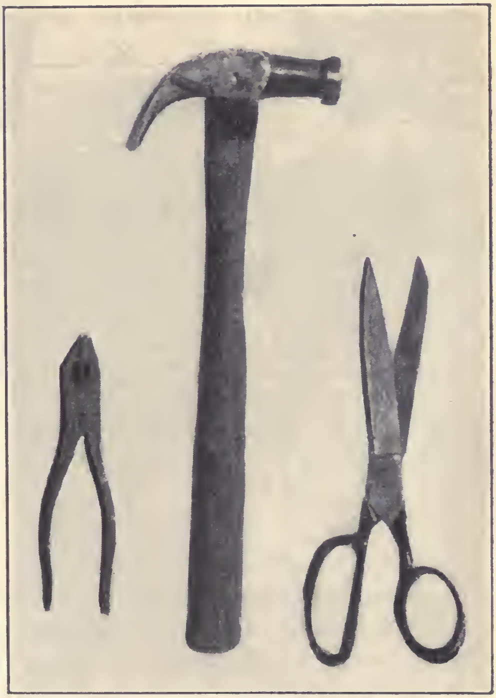


Fig. 68. Examples of levers.

5. Place the two books, one on top of the other, on one arm, *A*, six inches from the center. (Fig. 69) On the other arm, *B*, place one book of the same kind and move it back and forth until the stick balances. How many inches is the middle of the one book from the middle of the stick? **6.** Try the experiment again and place the first two books eight inches from the center. Then place the other book till the stick balances.

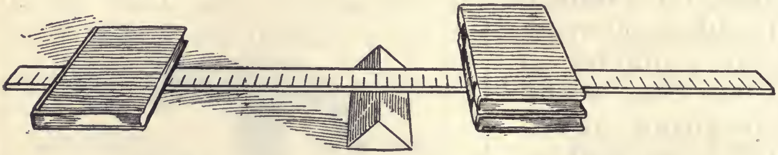


Fig. 69. Experiment with lever.

Make a record in your notebook like the following, filling in the proper lengths in the fourth column:

	WEIGHT ON ARM A (number of books)	LENGTH OF ARM A FROM FULCRUM (inches)	WEIGHT ON ARM B (number of books)	LENGTH OF ARM B FROM FULCRUM (inches)
First trial	1	6	1	——
Second trial	2	6	1	——
Third trial	2	8	1	——

7. Study carefully the figures in the above column. Compare the two weights for each trial and then the two distances. Can you discover the relation that exists between these four figures? If one weight is one half as great as the second weight, how many times as far must it be placed from the center in order to balance? **8.** In the second case how does the distance through which the single book moves when teetered compare with the distance through which the two books move? Compare the products of the figures in the first two columns with the products of the figures in the last two columns.

9. Select three children of about the same weight. Go out on the playground and measure the length of one half of the teeter from the center to a point near the end where the distance measures an *even* number of feet. If one child sits at this point, see whether you can figure out where two children, each weighing the same as the first, must sit on the other end to balance the first child. After you figure the distance, measure it off and mark it on the teeter. Then let two children sit one on each side of this mark and one child on the other end. Does the teeter now balance? When teetering, who moves through the greater distance, a heavy child or a light child?

Fig. 70. A swing is a kind of pendulum.

B. The Swing

A swing is an illustration of a *pendulum.* (Fig. 70) There are three laws regarding the movement of a pendulum: (1) the number of times the pendulum swings (say, in a minute) does not depend upon the weight; (2) the number of swings does not depend upon the length of the arc through which the weight swings; (3) the shorter the pendulum, the greater the number of times it swings. Pendulums are sometimes used as a means of regulating clocks. (Fig. 71) If the clock gains time, the pendulum is made longer, because the longer pendulum requires more time to make one swing. On the other hand, if the clock loses time, then the pendulum is made shorter. Why?

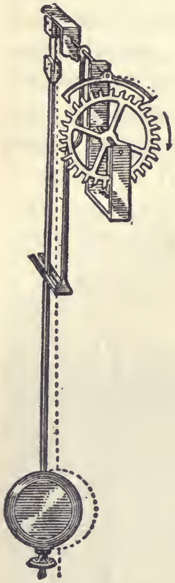


Fig. 71. A clock pendulum. From Brownell: ***Laboratory Lessons in General Science.***

Project 61 (G). Learning which will swing more times in a minute, a heavy child or a light child.

1. For these experiments with a swing, secure three large screw nuts (from bolts) of the same size, some string, and two screw eyes. **2.** Screw two screw eyes about six inches apart into a piece of wood an inch or two square and about a yard long. Place this across two desks or chairs, or support it in some other way so that strings can be suspended from the screw eyes. **3.** To one string tie one nut; to the other tie two nuts. Tie these strings to the two screw eyes so that they are of the same length. Start the two swinging evenly at the same time and see whether either one swings more times than the other. Try the experiment several times. What results do you get? What does the experiment show?

4. If you have two swings of the same length, let a heavy child sit in one and a light child in the other.

Start them equally at the same time and see whether either one swings faster than the other.

Project 62 (G). Learning which makes more swings in a minute, a child who is swinging through a short distance or one who is swinging through a long distance.

1. Use the same apparatus as in Project 61. Tie an iron nut to a piece of string and suspend it where it can swing freely. Pull the nut back about six inches and let go. Hold a watch in your hand and count the number of swings the nut makes in a minute. **2.** Start it again and pull the nut back twelve inches. Let go and count the number of swings in a minute. What results do you get? What does the experiment show? **3.** Suspend two nuts with strings of equal length. Pull one nut back six inches and the other twelve inches and set them swinging at the same time. Does either make more swings than the other?

4. If you have two swings of the same length, let two children of about the same weight sit in them. Start them both at the same time, one with a short swing and the other with a longer swing. Does either one make more swings than the other?

Project 63 (G). Learning which makes more swings in a minute, a child in a long swing or one in a short swing.

1. Use the same apparatus as in Project 61. Suspend the nut so that the string is about a foot and a half long. Count the number of swings it makes in a minute. **2.** Shorten the string until it is about a foot long. Now how many times does it swing in a minute? **3.** Make the string two feet long. How many swings does it make in a minute?

5. If you have two swings of different lengths, let a child sit in each and start them swinging at the same time. Which one swings more times per minute?

CHAPTER VIII

STARS AND CONSTELLATIONS

Many years ago the stars were divided into groups, called *constellations*, and given names. In most cases there is no similarity between the names of these constellations and the way in which the stars are arranged. However, the Big Dipper (Fig. 72) does suggest the outline of a dipper, and the Sickle is much like a sickle with the handle and curved blade. (Fig. 143) With a little imagination one can find in the constellation Orion, the shoulders, belt, heels, and sword of the hunter. (Fig. 141)

Some of the star myths. Many hundreds of years ago the ancient Greeks and Romans had many myths, some of which relate to the constellations of stars. One myth refers to several constellations found among the circumpolar stars, that is, the stars around the pole. According to this myth, the queen, Cassiopeia, was the wife of King Cepheus, and lovely Andromeda was their daughter. The vain queen had boasted that she was more beautiful than any of the sea nymphs. In anger the nymphs sent a dragon which killed people along the shores. Cepheus was told that this monster would not leave till he chained his daughter Andromeda at the edge of the water, where the dragon could reach her.

And so Andromeda was left there. But just as the dragon was about to devour Andromeda, she was rescued by a hero, named Perseus, who killed the dragon. As a reward for saving his daughter, Cepheus allowed Perseus to marry her. When these people died, they were changed by the gods into stars and placed in the heavens, where they can still be seen. Cassiopeia's enemies caused her to be placed in such a position that for half the time every night she is held with her head downward in order to teach her the lesson of humility.

There is also a myth about the Great and Little Bears, or Dippers. Juno, one of the ancient goddesses, was so jealous of a beautiful woman, named Callisto, that she changed her into a bear. One day Callisto was met by her son, who was hunting, and not knowing who she was, was about to shoot her. Thereupon Jupiter interfered and changed them both into constellations, the Great Bear and the Little Bear, and placed them in the heavens. In order to appease the jealousy of Juno, he placed them in such a position that they never sink beneath the ocean.

There are several myths about the winter constellations. One refers to Orion who was a great hunter. One day as he was walking in the woods, he discovered seven sisters known as the Pleiades, the nymphs of the goddess Diana. He followed them and they became frightened. To protect them, Diana changed them into pigeons, which flew upward into the sky, where they were changed to stars. Later, one of the seven deserted her sisters, thus leaving six in the group. These six have often been called the six sisters; they were so affected by the loss of their sister that they have looked pale ever since.

Orion was accidentally killed by Diana, and she, in order to show her sorrow, placed him as a constellation in the heavens, together with his two dogs, Sirius and Procyon. There he stands with arm uplifted, ready to strike the bull with its flaming eye, Aldebaran; and farther away the Pleiades still flee from him.

The "dogdays" of middle summer have been so named because at this time of the year Sirius, the Dog Star, rises at about the same time as the sun. It is stated in rhyme as follows:

When Sirius, rising with the sun,
Marks the dogdays well begun.

Castor and Pollux were twin brothers who were greatly devoted to each other. Castor was famous for managing horses and Pollux for his skill in boxing. When Castor was slain in battle, Pollux was so sad that he begged Jupiter to let him die also. Accordingly, in order that the brothers might not be separated, Jupiter placed them as stars in the heavens. The ancients believed that these stars had a favorable influence over the travel of boats. The expression, "by Jimminy," which we sometimes hear to-day, was derived from an old expression, "by Gemini" (*twins*), which was an ancient oath often used by sailors.

There is much pleasure in being able to name some of the more conspicuous constellations of stars. For the sake of convenience these may be divided into three groups: first, those that can be seen on any clear evening of the year; second, those seen during the late summer and in autumn; and, third, those seen during the winter.

The following is a table of some of the more conspicuous constellations and stars of the first two groups. In the first column of the summer and autumn constellations is given a list of the constellations, and in the second column the brightest star in that constellation. A star of the first magnitude is one that is very bright. There are no stars of the first magnitude in the circumpolar constellations.

CIRCUMPOLAR CONSTELLATIONS — SEEN AT ANY SEASON

Big Dipper (Ursa major)
Little Dipper (Ursa minor)
Dragon (Draco)
Cepheus
Cassiopeia's Chair

SUMMER AND AUTUMN CONSTELLATIONS

Constellations	*Bright Star (first magnitude)*
Bear-driver (Boötes)	Arcturus
The Virgin (Virgo)	Spica
The Lyre (Lyra)	Vega
Scorpion (Scorpio)	Antares
Northern Cross (Cygnus)	Deneb
Eagle (Aquila)	Altair

Project 64 (I). Learning to name the constellations that can be seen on any clear evening of the year.

1. Some stars never set, but circle around and around the North Star, never disappearing below the horizon.

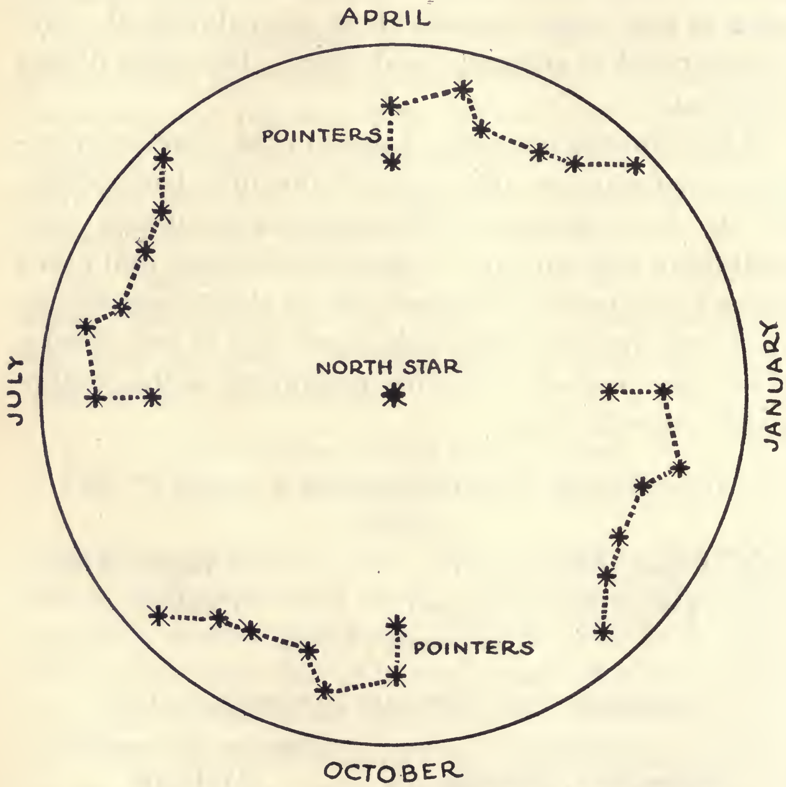


Fig. 72. Position of Big Dipper at 9 o'clock at different seasons.

These are called the *circumpolar constellations*. They may be seen on any clear evening during the year. They are seen in different parts of the sky in different seasons. (Fig. 72) A flash lamp will be of great help to you in using this book to locate the stars. By means of the lamp you can read the directions for finding each constellation and look at Figure 73. Then you can turn the lamp off and try to locate the stars in the heavens. Select some clear evening and go to an open space that is away from the glare of street lights. Stand facing the north and hold the book in front of you in such a position that the name of the month is at the top of the circle. (Fig. 73)

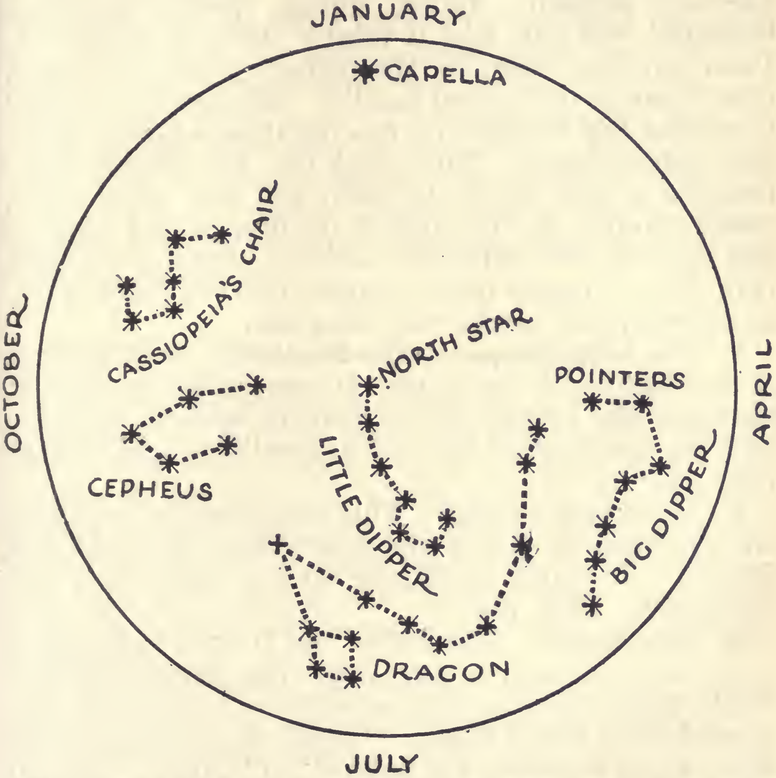

JANUARY
CAPELLA
CASSIOPEIA'S CHAIR
OCTOBER
NORTH STAR
POINTERS
APRIL
CEPHEUS
LITTLE DIPPER
BIG DIPPER
DRAGON
JULY

Fig. 73. Chart of circumpolar stars. When using chart, face north. To show the position of the stars at 9 o'clock for the different months, hold the chart with the name of the month at the top.

2. *The Big Dipper and the North Star.* The first and easiest group to find is the Big Dipper. This constellation is well named because it does look like a dipper. During autumn in the early evening, in the latitude of Boston, it is found low near the northern horizon; during spring, nearly overhead. Probably you can find it from a study of Figure 73. There are four stars at the corners of the bowl and three stars in the curved handle. After you have once found the Big Dipper you can use it as a means to locate other stars. Now look for the North Star. Imagine a line drawn between the two outer stars, called pointers, in the bowl of the dipper, and suppose this line to be extended several times its length (Fig. 73); it passes near a bright star, the North Star, no other equally bright star being near.

3. *The Little Dipper.* The North Star is at the end of the handle of the Little Dipper, which is smaller than the Big Dipper and extends in such a direction that the openings of the two dippers face each other. (Fig. 73)

4. *Cassiopeia's Chair.* This constellation is nearly on the opposite side of the North Star from the Big Dipper. It looks something like a chair or a flat capital W. (Fig. 73)

5. *The Dragon.* The tail of the Dragon begins at a point between the pointers of the Big Dipper and the North Star, and the body extends in a U-shaped line around the Little Dipper. It ends in a group of four stars, which represent the head of the Dragon. (Fig. 73)

6. *Cepheus.* After you have found the other polar constellations, you can find Cepheus by referring to Figure 73. It is located about midway between Cassiopeia and the head of the Dragon. Two of the stars in Cepheus point towards the North Star as truly as do the pointers in the Big Dipper.

7. After you have found the constellations, there are several ways in which you can make records in your notebook. As one way you can copy the figures from the book. Another way, which will prove more interesting, is the following: To represent the sky get some blue or black paper; to represent the stars get some silver- or gold-colored paper and cut out pieces in the form of stars; or you can buy stars at a bookstore at small cost. You might use two sizes to represent the brightness of the stars. Cut a piece of blue paper of the same size as your notebook and paste it on one of the pages. Make dots on this to represent the location of some of the brightest stars. Over each dot paste a star.

Project 65 (I). Naming the autumn constellations.

1. The circumpolar constellations are used as a guide in finding the autumn stars. If you do not already know these constellations, work out Project 64 first. In order to use the maps in Figures 74 and 75, you face toward the north and hold the book up in front of you. On a clear afternoon take this book home with you and soon after dark go outdoors to some open space away from street lights and locate the constellations as directed.

2. *Arcturus* in the bear driver. This star is more conspicuous in the summer, being nearly overhead in the early evening during June and July. In the autumn it is low down in the western sky. In order to find it at this season look in the early evening during the first part of September. Start with the Big Dipper and follow the curve of the handle for about twice its length, and it will end near the bright star Arcturus, which stands out conspicuously because there is no other bright star near it. (Fig. 74)

3. *Vega* in the *Lyre.* Start with the star at the junction of the bowl and the handle of the Big Dipper. Draw a line from this star to the North Star. Starting from the North Star, draw another line at right angles to the first line and on the same side as that from which the handle projects. Make this line about half as long again as the first line. (Fig. 75) It will end near the bright star Vega in the constellation of the Lyre. Near it are four small stars which form an oblique parallelogram (that is, a form something like a square, only the angles are not right angles). Of the two stars which form a triangle with Vega, the upper one is a double star. It is said that good eyes can distinguish the two stars. Have you good eyes?

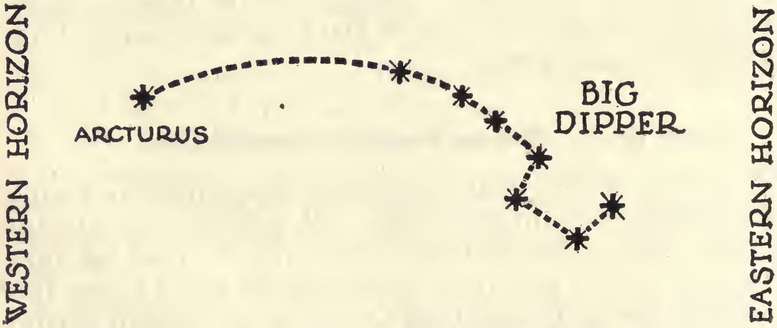


Fig. 74. Chart of Arcturus. When using chart, face north.

4. *Deneb* in the *Northern Cross.* Draw a line connecting Vega and the North Star. From each of these stars draw a line (on the side away from Arcturus) so that when they meet they will form a right angle. (Fig. 75) Near this meeting point is the star Deneb, at the head of the Northern Cross. The stars in this group form an irregular cross.

5. *Altair* in the *Eagle.* Start with the North Star and draw a line south through a point about halfway between Vega and Deneb; extend this line nearly as far again. (Fig. 75) It will end near the star Altair in

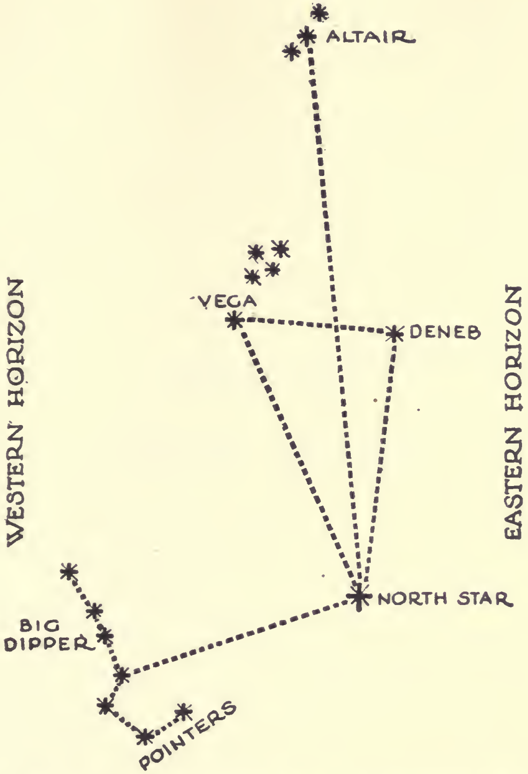

ALTAIR
VEGA
DENEB
WESTERN HORIZON
EASTERN HORIZON
NORTH STAR
BIG DIPPER
POINTERS

Fig. 75. Chart of Autumn stars. When using chart, face north. Position of Big Dipper at 9 o'clock in September.

the Eagle. On each side of Altair is a smaller star, the three being in a straight line.

6. Make records in your notebook as suggested in Project 64, paragraph 7 (page 119).

PART TWO

WINTER STUDIES

CHAPTER IX

WINTER BIRDS

Why should winter birds be fed? During the winter we find few wild animals and plants. Some of those which were present in the summer have died, some have migrated to a warmer climate, and some are so quiet that we do not see much of them. Hence those animals, such as birds, that we do find are all the more interesting. There are at least two reasons why you might wish to feed the birds; first, for your own sake, and second, for the birds' sake. You can have much pleasure in feeding the birds and watching their habits. At the same time you will be helping the birds. Snow and ice cover some of the food that birds usually find on the ground and on trees. In very severe winters some birds die from lack of food. For that reason you may be saving the lives of birds by feeding them.

What kinds of foods do the birds like? Two common kinds of food which the birds naturally eat are seeds and insects. For those birds that eat seeds we can supply such seeds as wheat, hemp, millet, and sunflower seeds, the last being especially good. While we cannot secure insects to feed the birds, a good substitute, which many birds like, is suet. What is suet?

How should the food be put out? The simplest way to put out food is to brush away the snow from a place on the ground and throw the food there. However, this is not a satisfactory method, because the food is often wasted. A better way is to make a shelf, which may be fastened to a tree. (Fig. 80) For putting out suet, a basket may be made out of a soap dish. (Fig. 81) For putting out grain and other seeds hoppers may be made similar to those used in feeding poultry. (Fig. 82) Directions for making these are given later on in projects on pages 130 to 132.

If a feeding shelf is placed on a window, birds often become so tame that they will fly to the window and

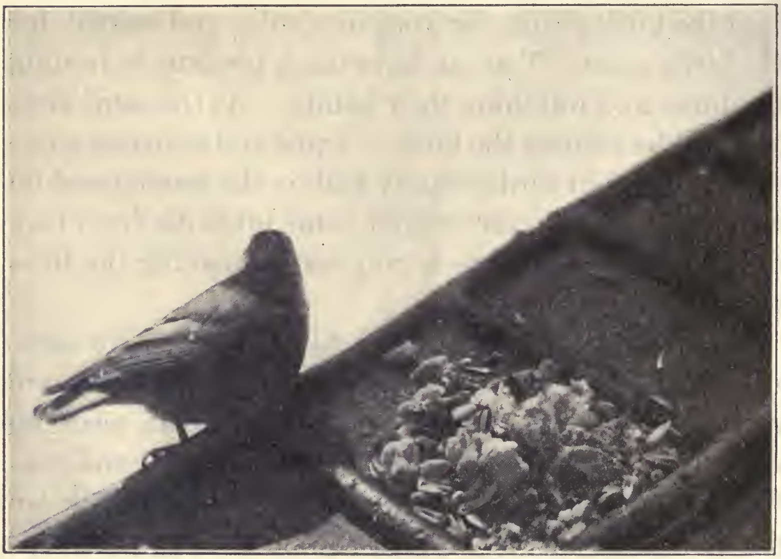


Photo by G. H. Trafton

Fig. 76. White-breasted nuthatch feeding at shelf on window sill.

feed there, even when people are sitting inside only a few feet away. (Fig. 76) A shelf of this kind gives a splendid chance to watch the birds because they come so close to the observer. If you are very much interested in birds and have considerable patience, you may be able to get the birds to feed from your hand. (Fig. 77)

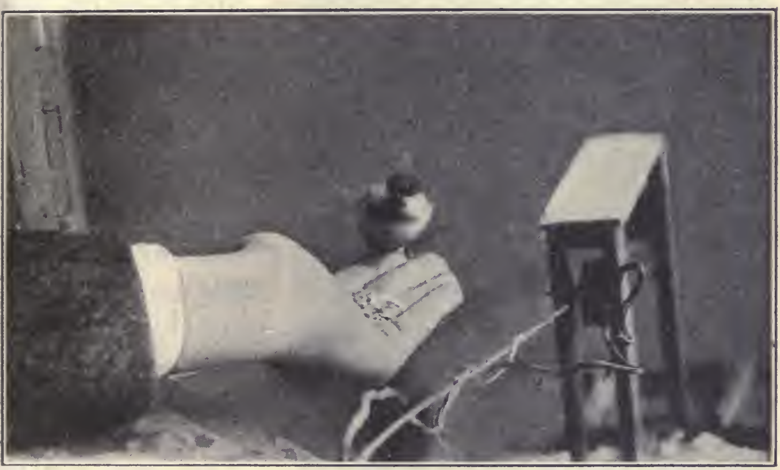


Photo by G. H. Trafton

Fig. 77. Chickadee feeding from boy's hand.

How do birds act around the lunch counter? Perhaps you will be interested to learn about some of the author's experiences with the winter birds; they may suggest some things that you can do; and you can compare your observations of birds with his. It happened that he began to write this chapter one clear winter day while sitting in his study facing a window through which he could watch the birds that came to his feeding counters which were located on a tree near the house. He had fastened to this tree a suet basket and a hopper filled with sunflower seeds. Sometime during the day the following birds came to feed: blue jay, chickadee, white-breasted nuthatch, hairy woodpecker, and downy woodpecker. (Fig. 78)

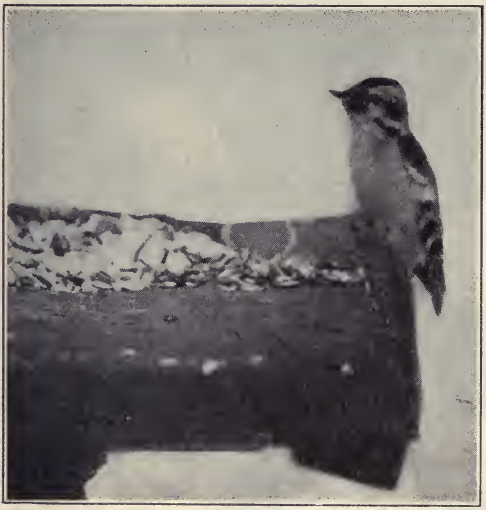


Photo by G. H. Trafton

Fig. 78. Downy woodpecker at lunch counter.

The two woodpeckers ate only the suet, while the white-breasted nuthatch, chickadee, and blue jay ate both suet and sunflower seeds. The blue jay usually flew directly to the food and after securing it flew away. The other birds, however, approached more leisurely. The chickadee flew from limb to limb on his way to his meal. The woodpeckers alighted on the tree trunk below the suet and climbed up the tree with a peculiar hitching motion as they teetered from tail to feet. White-breast alighted on the tree trunk above the suet and then walked down the tree *head first,* and while standing in this position ate the suet. (Fig. 79)

The blue jay takes the seed in his bill and crushes it; the chickadee carries a seed to a neighboring limb, and while he holds it with one foot, he picks off the coat around one end with his bill and then pulls out the seed. White-breast carries the seed to some crack in the bark of a tree, and after wedging it securely hammers it with his long, sharp bill till he cracks the coat of the seed. The author noticed that white-breast always took the seeds to the same crack. After the bird had carried seven or eight seeds to this crack, the author went out and looked at it to see whether he could find any reason why the bird had chosen this one spot. He found that it was the best crack for the purpose of holding a seed that could be seen on the tree. It was just the right size and shape to hold the seed securely. It was a new thought to the author that white-breast had any preference in selecting cracks. He had supposed that the bird took its seeds to any

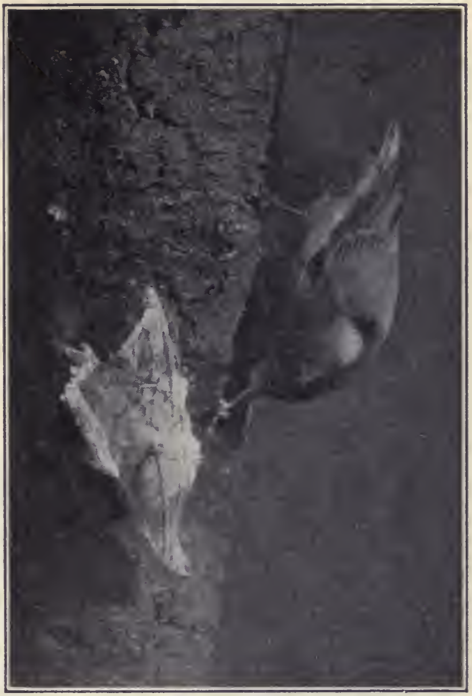


Photo by G. H. Trafton

Fig. 79. White-breasted nuthatch eating suet while standing head downward.

crack that was near. There is always a chance to learn something new about birds, things that are new not only to you, but things that perhaps no one else ever observed before.

White-breast, chickadee, and downy form a friendly group and are often found together, while the blue jay never associates with these birds, perhaps because he is so much bigger. Whenever the blue jay comes to the tree, the other birds leave and do not return as long as he is there.

If you put out food and birds come to it, watch the habits of the birds and see whether they act the same as those the author has been telling you about.

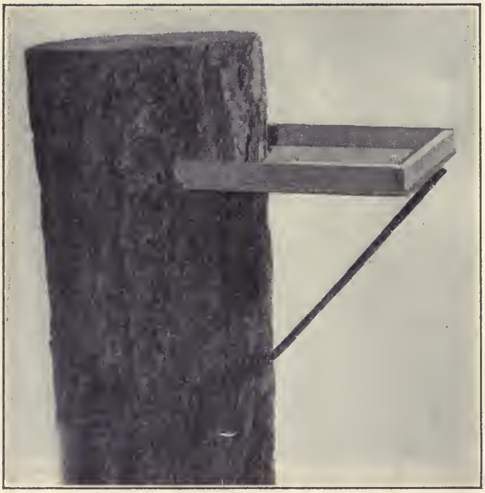


Fig. 80. A simple but effective feeding shelf.

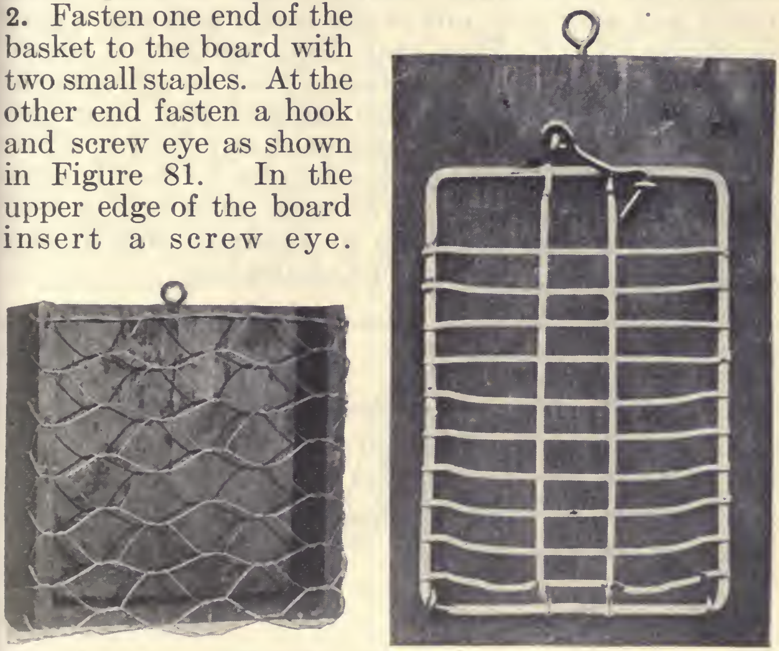
Project 66 (1). Making a feeding shelf for the birds. (Fig. 80)

1. Get a piece of thin board about nine or ten inches long and six or eight inches wide. **2.** Cut one of the long edges in the form of a curve so that it will fit around a tree trunk. **3.** On the other three sides nail narrow cleats of wood about an inch wide, such as laths. **4.** To fasten up the shelf, get a lath about a foot and a half long. Hold the shelf against the tree and drive a nail slantingly through the inner edge of the shelf into the tree. Place the lath so that one end rests against the outer edge of the shelf and the other end against the tree below. Fasten the lath in this position by driving in nails.

Project 67 (I). Making a suet basket.

1. Get a soap basket like that shown in Figure 81 and a piece of board a little larger than the basket.

2. Fasten one end of the basket to the board with two small staples. At the other end fasten a hook and screw eye as shown in Figure 81. In the upper edge of the board insert a screw eye.



Made from wire poultry netting. Made from soap dish.

Fig. 81. Two kinds of suet baskets.

3. Fill the basket with suet and hang it up on a tree or post by means of a hook.

4. You may also make a suet basket in another way. (Fig. 81) Secure a piece of board five or six inches square. Around three sides nail strips of narrow board about an inch and a half wide. Over this fasten a piece of hardware cloth or of poultry netting with small meshes. In the top end fasten a screw eye. The suet lies under the meshes.

Project 68 (I). Making an automatic feeder for seeds.

1. This is made on the same principle as the ones often used in feeding poultry. Get thin pieces of board and saw them out in the shape and size shown in Figure 82. **2.** Then nail them together as shown in the figure. **3.** If you follow closely the dimensions given in the figure and notice carefully how the pieces are put together, you will not need any further directions. The dimensions of this plan are for boards three eighths of an inch thick. The same plans may be used for boards of any thickness by changing slightly one of the dimensions of the roof and the floor.

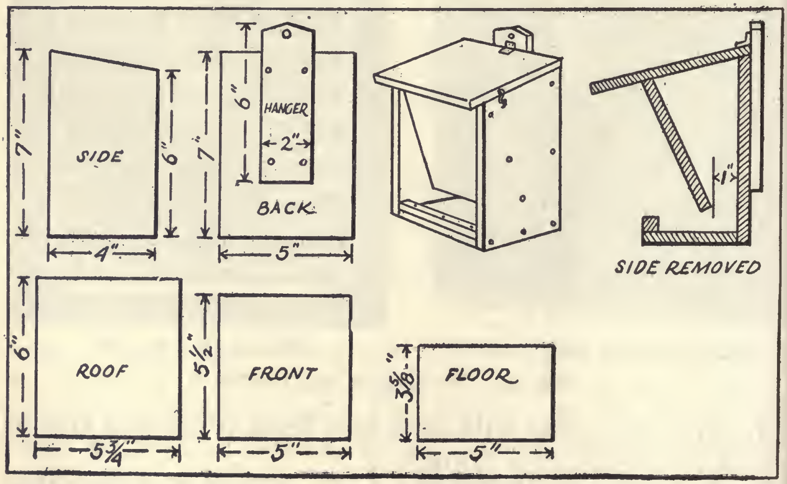


Fig. 82. Plans for automatic feeder. Dimensions of roof and floor are for three-eighths inch board.

Project 69 (I). Observing the habits of the birds that come to the lunch counter.

1. You can have much pleasure by watching the habits of the birds and seeing what they do. In the first place you will want to learn the names of the birds that come, the same as you learn the names of your playmates. It will not be difficult to find out the names of the birds, because they come so close and stay so long. Get some bird book with colored pictures and look it through till you find the bird. Or perhaps your teacher can tell you the names of the birds if you give a careful description of them. Learn also the names of the birds from the sounds they make.

2. Put out several kinds of food, such as suet, sunflower seeds, peanuts, wheat, bones, bread crumbs, and various scraps of food. Notice what kinds of food each bird eats. Does it seem to like one food better than another? **3.** Notice the different ways in which the birds approach the food. **4.** What is the difference in the way the birds crack the sunflower seeds? **5.** Which birds seem to be most friendly with each other? **6.** At what time in the morning do the birds begin to come? **7.** In what kinds of weather do most birds come? **8.** Write in your science notebook the most interesting things you observe about the birds.

CHAPTER X

TREES IN WINTER

A. Evergreens

How do Christmas trees differ from other trees? Trees are divided into two groups according to the length of time they hold their leaves. Some trees bear leaves all through the year, and are called *evergreens;* other trees drop their leaves in the autumn, and are called *deciduous.* However, the leaves of the evergreen fall, too, only instead of all falling at one time, they may fall at any time of the year, but usually after staying on the trees several years. Thus there are some leaves on the tree all the time. The larch is different from the rest in that it drops all its leaves in the autumn. When seen in the winter, it looks like a dead evergreen tree. Our Christmas trees belong to the evergreen group.

The more common kinds of evergreens found growing in the eastern and northern parts of the United States are: hemlock, red cedar, arbor vitæ, larch, pine, fir, and spruce. The last three are the kinds used for Christmas trees, the spruce being the one used most commonly.

If you compare the leaves of the evergreens with those of other trees, you find a great difference in their shapes.

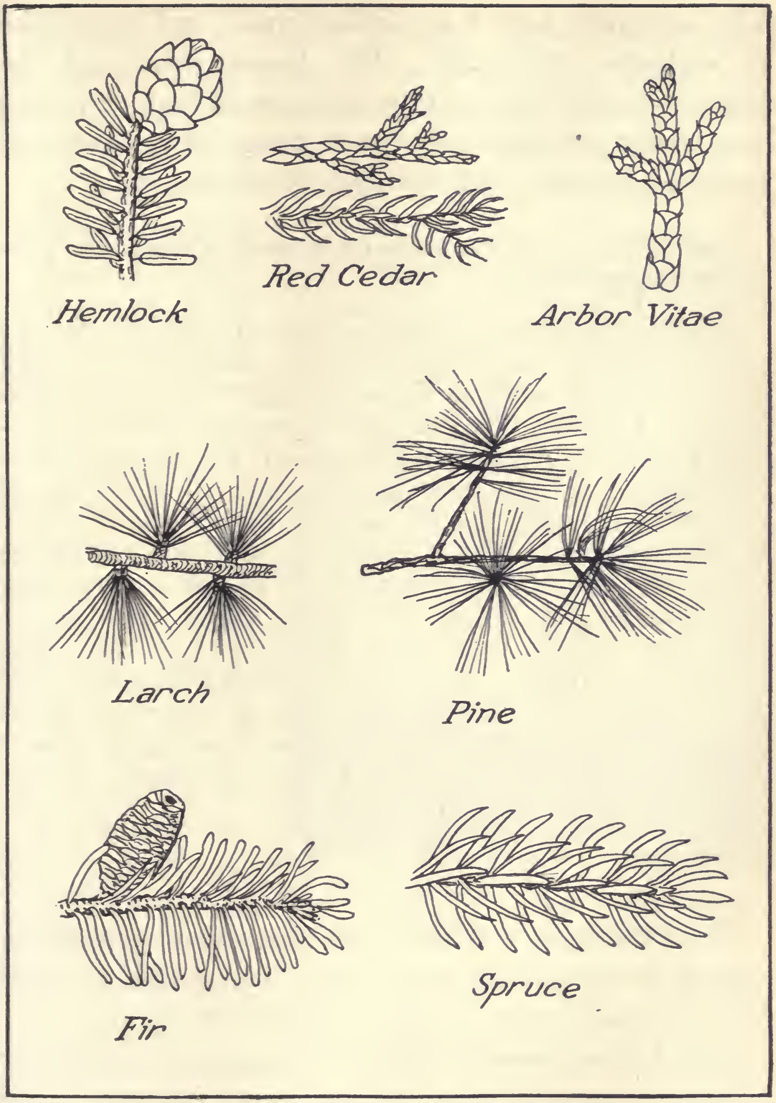

Hemlock
Red Cedar
Arbor Vitae
Larch
Pine
Fir
Spruce

Fig. 83. Leaves of evergreen trees.

The evergreen leaves are either small and needlelike or scalelike. (Fig. 83) The leaves withstand the snows of winter because they are so small that snow does not gather on them and break them off as much as would be the case with ordinary broad leaves.

Project 70 (G). Learning how many kinds of evergreens grow in your neighborhood.

1. After Christmas bring a twig of your Christmas tree to school and see how many different kinds of trees you find among those brought by your classmates. **2.** Then bring to school twigs of as many different kinds of evergreens as you can find growing near your home. Bring in also specimens of the fruit, if you find any, such as the cones of the pine and spruce. **3.** Notice how the leaves differ so that you can name the trees and tell them apart. (Fig. 83) Following are some of the things to notice about the leaves: their size, shape, stiffness, arrangement on the stem (whether opposite or not), and grouping (whether single or in clusters, and if in clusters, how many in a cluster). **4.** How do the fruits differ from each other? **5.** Make drawings in your science notebook of the different kinds of leaves.

B. DECIDUOUS TREES

There are many interesting features about trees in the winter, if one studies them, and a knowledge of these features enables one to enjoy outdoor life better.

How do trees branch? During the summer the mantle of leaves covers the trees; during the winter, when these have fallen, some features of the tree, such as the branching, are seen more clearly. In some trees, such as the elm, the main trunk divides low down into several branches of about the same size, giving the tree a fanlike appearance. (Fig. 84) In another type of branching, as seen in most evergreens, the main trunk extends straight up through the tree, giving off small side branches. (Fig. 85) Many trees have a method of branching which is intermediate between these two types.

How do trees differ in shape? Closely related to the branching is the shape of trees. Evergreen trees are cone-shaped (Fig. 85); the elm is fan-shaped (Fig. 84); the lombardy poplar is spire-shaped (Fig. 86); the sugar maple is oval or egg-shaped.

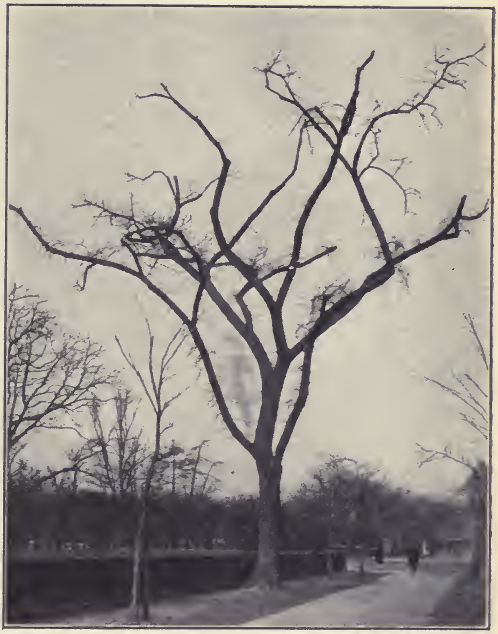
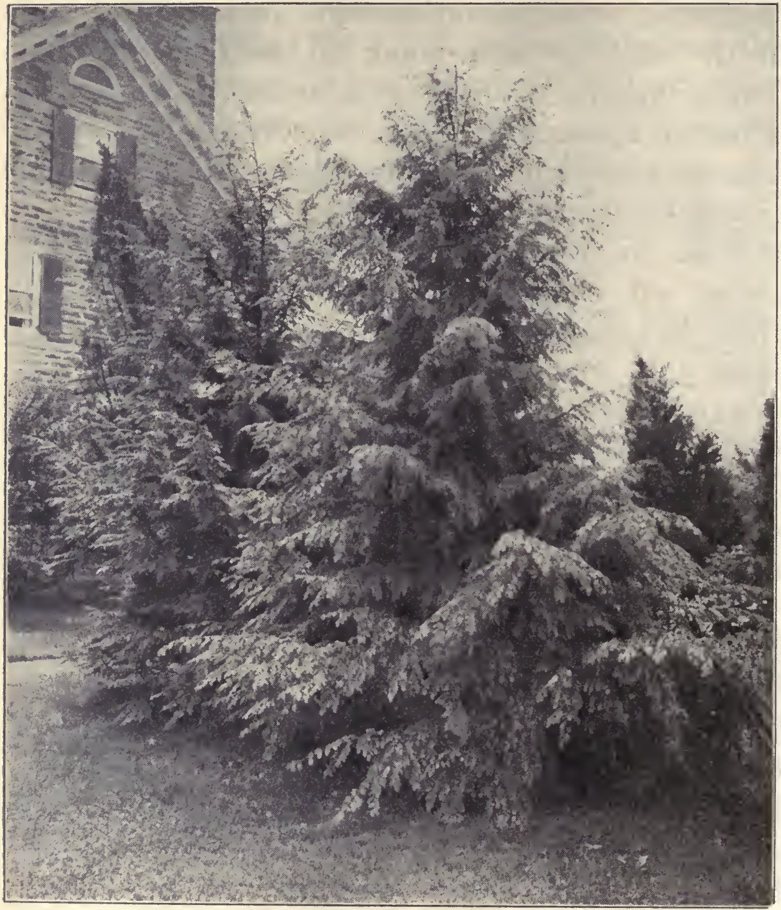


Photo by Ewing Galloway, N. Y.

Fig. 84. Elm tree in winter. From Blakeslee and Jarvis: *Trees in Winter.*

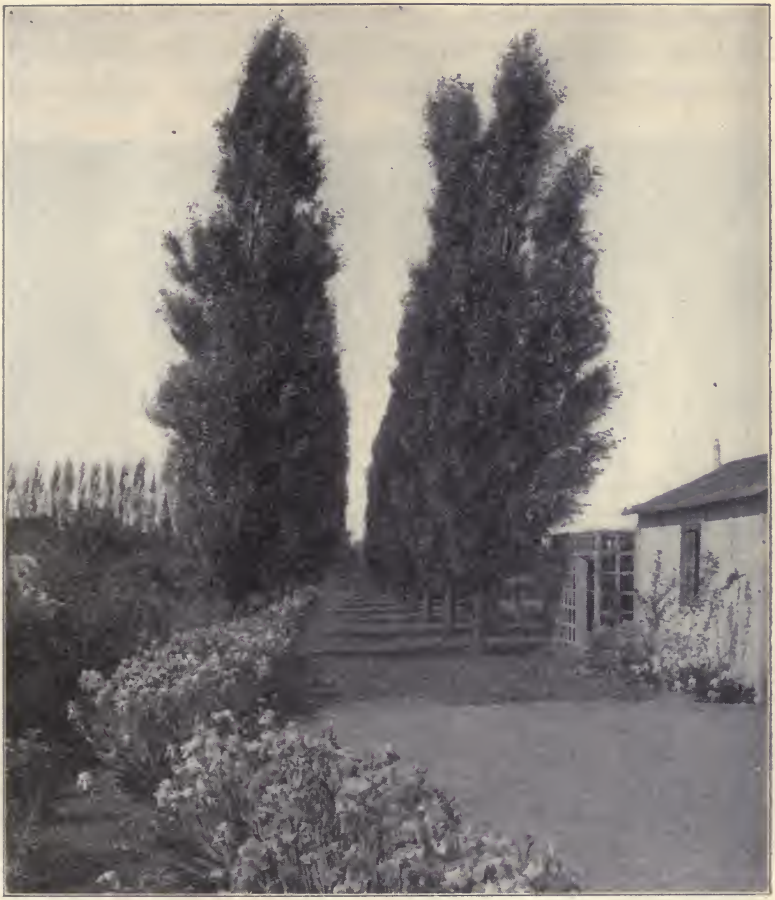
How do the barks of trees differ? Barks may differ in roughness and color. Most barks are dark colored and inconspicuous. The bark of the canoe birch, however,



© *J. Horace McFarland Co., Harrisburg, Pa.*

Fig. 85. An evergreen tree.

is noticeable for its white color. On some trees, such as the silver poplar, the bark of the upper part of the tree is conspicuously light-colored, while the bark of the lower trunk is dark. The bark of most trees is rough,



© J. Horace McFarland Co., Harrisburg, Pa.

Fig. 86. Lombardy poplar.

with some exceptions such as the beech and the canoe birch. Some barks peel off easily; the bark of the shagbark hickory peels off up and down the trunk, while that of the white birch peels off around the tree. (Fig. 87)

How do the twigs of trees differ? To see other differences requires a closer view of the twigs. The tree bears certain parts, such as leaves, fruit, and scales, which fall off sometime during the year and in so doing leave scars on the twigs. (Fig. 88) The scars of the leaves are especially noticeable. These differ so much in shape, size, and arrangement that one can tell the

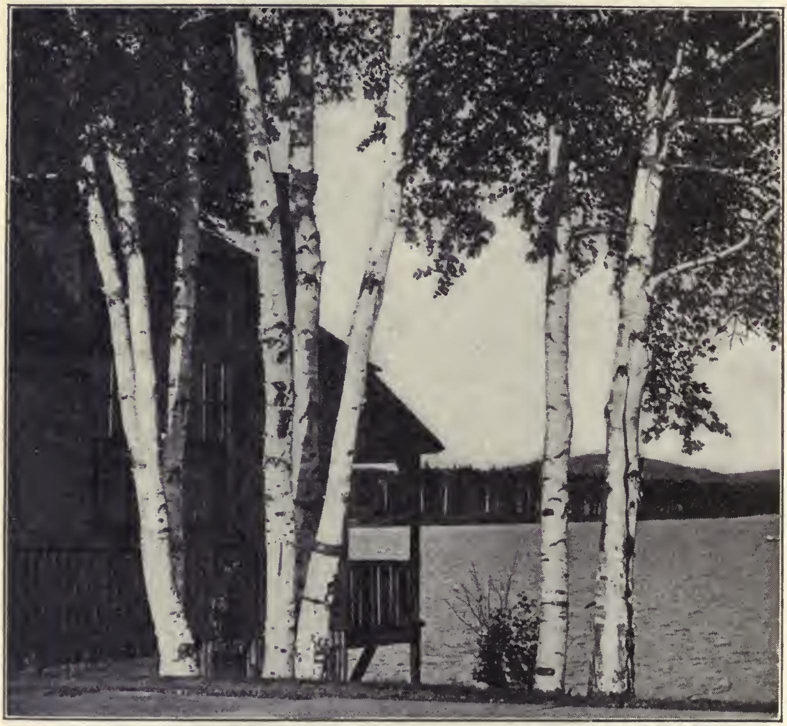


Photo by Ewing Galloway, N. Y.

Fig. 87. White birch. A photograph of the trunk showing the characteristic bark markings: white peeling off in horizontal layers; lenticels elongated horizontally.

name of the tree from them. (Fig. 89) Inside the leaf scars are other little scars, called *bundle scars*, which differ in number and arrangement.

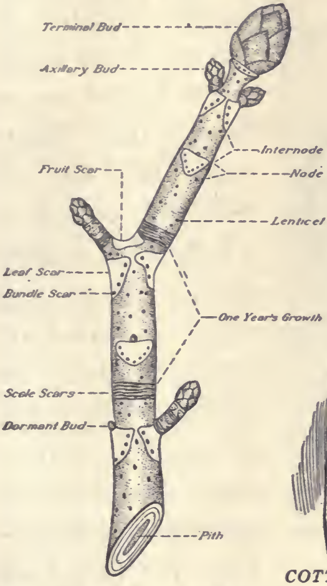
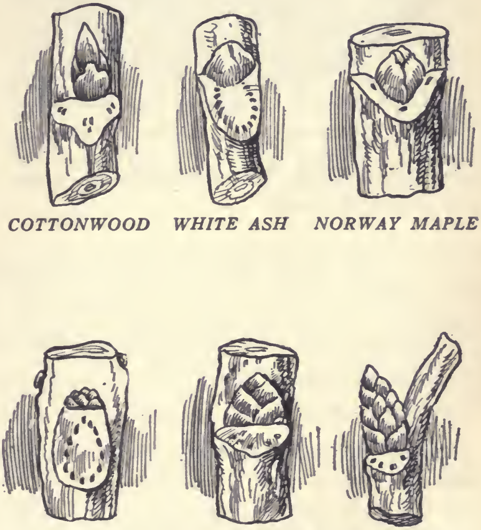

Terminal Bud
Axillary Bud
Internode
Node
Fruit Scar
Lenticel
Leaf Scar
Bundle Scar
One Year's Growth
Scale Scars
Dormant Bud
Pith

Fig. 88. Twig of horse chestnut, showing scars.

There is a difference also in the shape and size of the buds of the trees. (Fig. 89)


COTTONWOOD *WHITE ASH* *NORWAY MAPLE*

CATALPA *CHESTNUT* *AMERICAN ELM*

Fig. 89. Leaf scars and buds of a few trees.

How may the age of twigs and trees be told? Most buds are covered with scales; and when the bud begins to grow in the spring, these scales fall off and leave scars, which are usually arranged as a series of rings around the stem. The last scars show where the twig began to grow in the spring, and the distance from the tip of the bud to the nearest set of scale scars is the amount that the twig grew during the last season. (Fig. 88) By counting the number of series of these scars found on a twig, one may learn the age of the twig. Again, if a twig is cut square across, there appears a series of rings, known as *annual rings*, each of which represents one season's growth. Therefore by counting these rings the age of the twig may be determined. (Fig. 90) In this way the age of an entire tree may be learned by counting the rings on the stump after the tree is cut down.

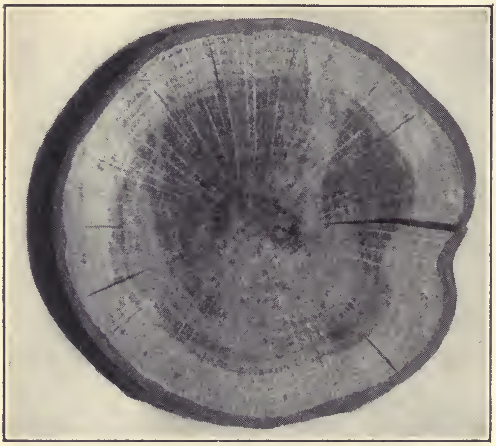


Fig. 90. Section of red-oak stem showing annual rings. It also shows pith rays, summer wood, spring wood, heartwood, and sapwood. Can you find them all?

Project 71 (I). Naming trees in winter from their study outdoors.

1. Select a few of the most common trees near your home or school and observe the following points about each tree. **2.** What is the shape of the whole tree? Does either of the following terms describe it: *cone-shaped, fan-shaped, spire-shaped,* or *egg-shaped?* **3.** How does the main trunk of the tree branch? Does it divide into several branches like the elm, or does the main branch extend up to the top of the tree like an evergreen? **4:** What are the noticeable features about the bark? What is its color? Is it rough or smooth? Does the bark peel off?

Project 72 (G). Naming deciduous trees from an indoor study of twigs and fruits.

1. Cut off twigs about a foot long from a number of different kinds of trees and bring them into the schoolroom. **2.** Take two twigs at a time and notice how they differ. **3.** How do the buds differ in shape, color, and size? **4.** Compare the leaf scars. How do they differ in shape, size, and the way they are placed on the stem? Inside of the leaf scars are little dots called bundle scars. How do these differ in number and in the way they are arranged within the leaf scar? **5.** Compare the fruits and notice how they differ. **6.** Make a drawing in your science notebook of one or two twigs.

Project 73 (G). Learning the age of twigs and trees.

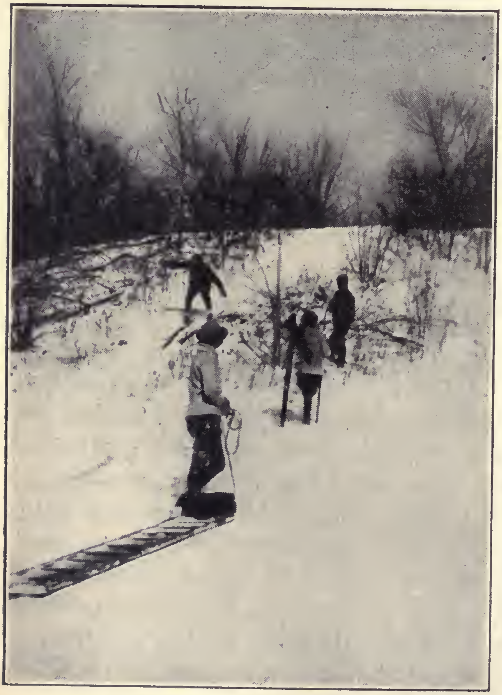
1. To learn the age of a twig, cut across it squarely with a sharp knife. Count the rings. **2.** As another method count the number of series of scale scars on the twig. Do you get the same answer by both methods? **3.** How many inches did the twig grow last season? **4.** To find the age of a tree, count the number of rings in a stump. Measure the diameter of the stump. Divide this by its age in order to learn how much growth the tree averaged in one year. Perhaps you can saw a few inches off an unsplit hickory, elm, or oak branch from the woodpile at home, and bring it to school to show the rings.

CHAPTER XI

OUTDOOR WINTER SPORTS

A. Coasting

How much fun the winter brings: *coasting, tobogganing, skiing,* and *skating!* Perhaps sometimes you think you like the summer better than the winter, and again you think you like the winter better. It is a good thing that you have a change every year, as you might become tired of the same kind of sport all the year round.



Courtesy of Roy Anderson

Fig. 91. Fun the snow brings.

What do you get the most fun out of — snow or ice? Coasting is one outdoor winter sport you can enjoy just as long as there is snow on the ground, if there are any hills around. (Fig. 91) Probably the snow brings more fun than ice for two reasons; first, because the time in which to enjoy the snow is longer. After the first snow comes, the ice is covered; then there is no more skating unless someone clears away the snow.

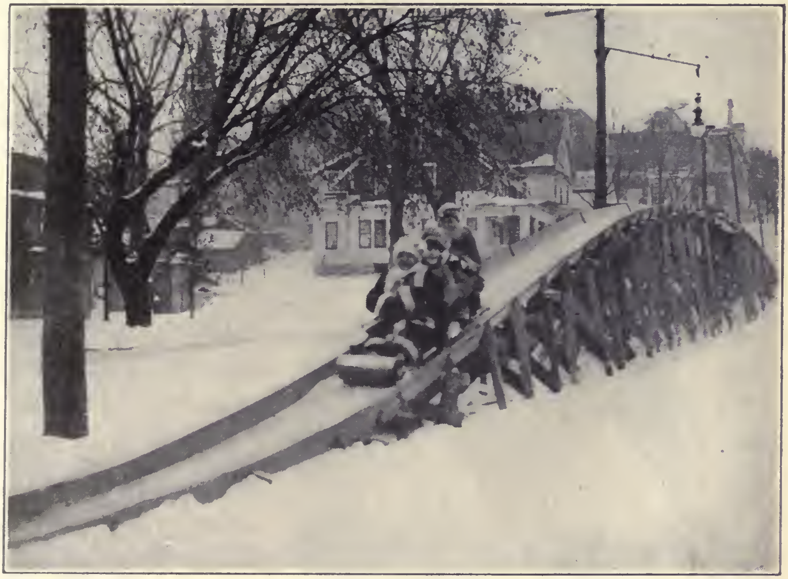


Fig. 92. A toboggan slide.

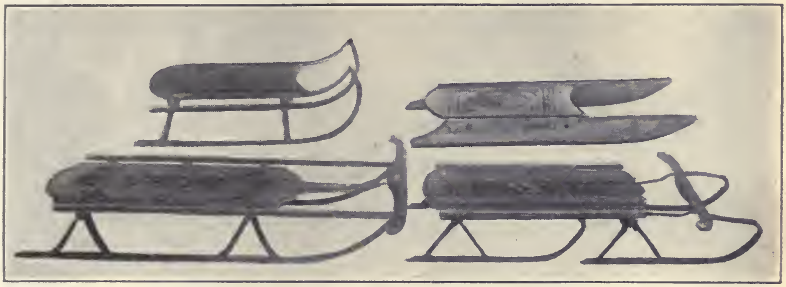
Second, it is much easier to learn to slide than to skate; in fact, there isn't much that one must learn about coasting, except the steering.

The kinds of sleds. A combination of snow and a hill gives three kinds of sport: coasting, tobogganing (Fig. 92), and skiing (Fig. 93). Several kinds of sleds have been used (Fig. 94). There is the low sled known as the cutter, the ordinary high sled, the steering sled or flexible flyer, which can be steered by twisting the front of the sled from side to side, and finally the bobsled, which may be made in two ways. In one kind of bobsled two sleds are fastened together with a board so that the front sled can be turned. Another kind can be bought already made and consists of one framework with two small sleds attached, the first movable to right and left.

Photo from Ewing Galloway, N. Y.

Fig. 93. Ski jumping.

What are the composition and forms of snow? Snow is made of a great many beautiful crystals of which there are many different kinds. (Fig. 95) One man who has made a specialty of photographing these crystals has found thirteen hundred distinct kinds and has never found any two just alike.



Girl's sled
Flyer type

Boy's sled
Auto-bob

Fig. 94. Different kinds of sleds.

Project 74 (I). Studying the appearance of snow crystals.

1. Sometime during a snowstorm catch some snowflakes on a piece of dark cloth or on your sleeve, and look at them with a magnifying glass. Also make a study of pictures of snow crystals. (Fig. 95) **2.** How many different shapes do you find? Do you find any two just alike? Make drawings of a few in your science notebook.

Under what conditions does snow form? In some parts of the country neither snow nor ice form. Snow and ice are simply different forms of water; and in order to have them form, the temperature must be below the freezing point (32 degrees Fahrenheit). Snow comes directly out of the clouds as snow. It does not first form as rain and then change to snow. After snow has fallen, however, and stood under pressure it often changes into ice. Perhaps you have observed this fact

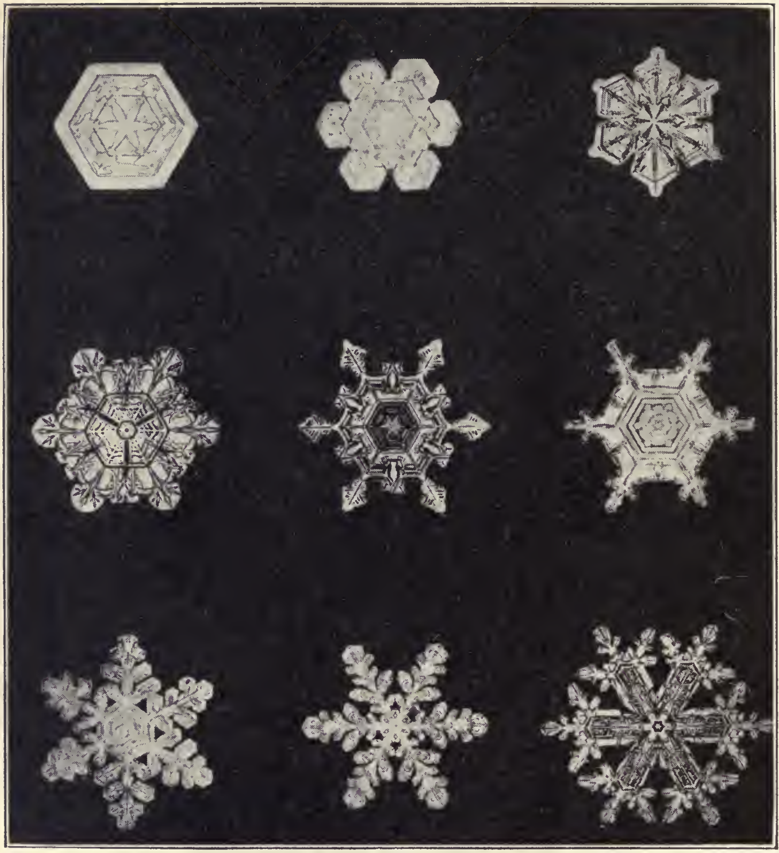


Fig. 95. Snow crystals.

when making snowballs or in the bottom of a great snow bank. Glaciers and icebergs are formed from snow.

Project 75 (G). Performing an experiment to find out whether a sled with two children on it goes faster or slower than a sled with only one child on it.

1. To take the place of a hill get a short piece of board, planed smooth on one side. In place of the sled get some marbles. Get two of about the same size, but of different weights. **2.** Support one end of the board so as to give a sloping surface like a hill. Start the two marbles at the top of the board. In order to start the marbles at the same time hold a pencil across the top of the board with the marbles resting back of the pencil. Then quickly lift up the pencil. See whether they both reach the bottom at the same time. Try several times till you are sure of the result. If you are in doubt, get a longer board.

3. To help answer our question in another way, get a nickel and cut out a round piece of paper a little smaller than the coin. Hold the nickel horizontally between the finger and the thumb with the piece of paper on the top. Drop the coin and see whether it reaches the floor before the paper. **4.** How will you apply your conclusions to the problem stated at the beginning of this project?

B. SKATING

Skating is a good winter sport. First, it gives good exercise; second, it takes one outdoors in the fresh air; and third, it furnishes a great deal of pleasure. In the late autumn and early winter there are usually plenty of places to skate. You and your companions might form a skating club and plan to keep a small piece of ice cleared of snow when it comes. Shovels and horse scrapers can be used to clear off most of the snow, and then brooms will be needed to brush the ice off clean. The fun will more than pay you for the work. (Fig. 96)

Why does ice form on top of a pond? Sometime, when you are watching a pond freeze over for skating, you may wonder why ice forms on the top of the pond instead of the bottom. The change of water to ice is such a common happening that you probably haven't thought much about it. You know that water pipes often burst when the water freezes. This bursting is due to the fact that when water changes to ice it expands, and so takes up more room. The force of this expansion breaks the pipes. The same increase in size takes place when water in a pond freezes. As a result of this expansion, ice becomes lighter than water, bulk for bulk, and hence floats.

Courtesy of Fred Hanson

Fig. 96. A skating pond.

It is a general rule among other liquids that when they become solid, they shrink, or contract, and become heavier. If this rule were true of water, you can easily see what would happen; the ice would sink to the bottom of the pond. There would be no skating until the pond was frozen solid, and in deep ponds or lakes this would never happen. You might see the ice down in the water, but you couldn't skate on it. Even in shallow ponds, when the ice did freeze to the top, it would probably be too rough for good skating.

Project 76 (G). Finding out how much of floating ice is below water.

1. Procure a piece of ice of such size that it will float in a pail of water. Trim off the ice so that it is of reg-

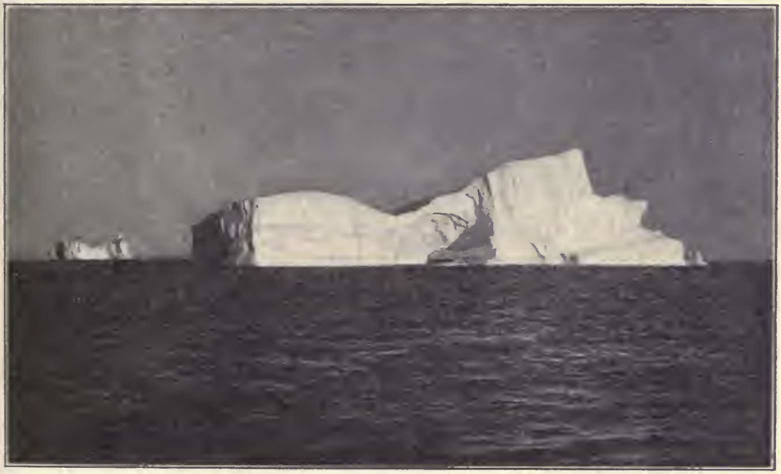


Photo from Ewing Galloway, N. Y.

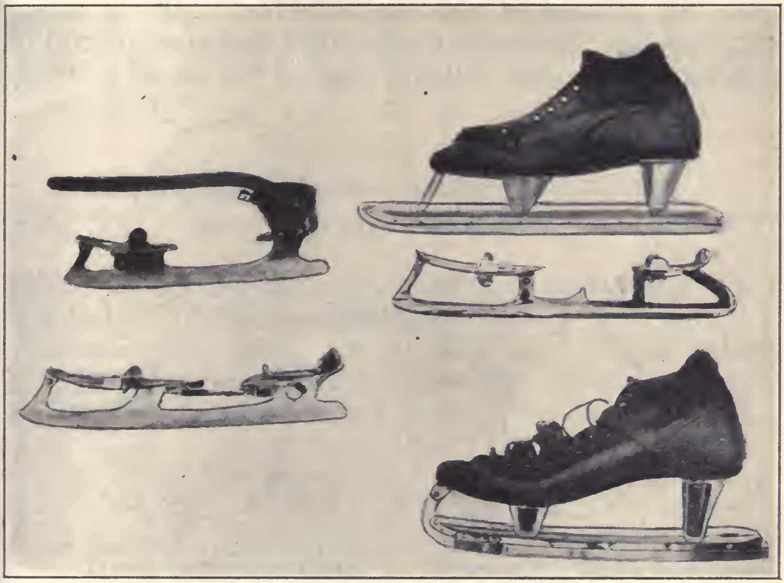
Fig. 97. A floating iceberg. The bulk of floating ice below the surface is about eight times as great as that above the surface of the water. From Peabody and Hunt: *Biology and Human Welfare.*

ular shape with square edges, more like the blocks of manufactured ice you have seen the iceman deliver. **2.** Measure the height in inches. Put the ice in a pail of water and measure the part of the ice that is under water. What fraction is this of the total height? What fraction, then, of floating ice is out of water? **3.** If 100 feet of an iceberg of regular shape stands above water, about how high is the entire iceberg? (Fig. 97)

How many kinds of skates are there? There are several kinds of skates. According to the curve of the blade, they may be divided into three classes: *speed*, *figure*, and *hockey* skates. (Fig. 98) The speed skate is long and straight, so that nearly all the blade is on the ice at the same time. It is built for speed. The figure skate is short and round on the bottom, for fancy skating. The hockey skate is halfway between these two. It is flat enough so that a fair degree of speed can be obtained but curved enough so that corners can be turned easily.

Skates also differ according to the way in which they are attached to shoes. Some are fastened to the soles of ordinary shoes by means of a lever clamp; some are fastened by means of a screw which tightens up the clamps. Other skates are fastened permanently to special shoes that come with the skates.

How do the motions in skating differ from those in walking? While the only way to learn how to skate is to put on a pair of skates and go out on the ice, a few suggestions may help. The first point is that the motion of the foot in skating is different from that in walking. In walking, the foot goes straight ahead and at the end of the step the weight is on the toe. In skating, the rear foot moves to the side and backwards, and the whole bottom of the foot is kept nearly flat on the ice all the time. Try to keep these two points in mind. Another difference is that in skating the body sways from side to side, and the movements of the leg are slower, with a slight pause between the strokes as the body glides along on one foot.



Girl's half hockey
Boy's lever

Tubular speed
Canadian clamp hockey
Tubular figure

Fig. 98. Different kinds of skates.

After you have learned to skate well enough so that you can skate forwards easily and go around turns, you will next be interested to learn some figure skating.

Project 77 (I). **Learning to do the figure eight.**

1. The beginning of fancy skating is the figure eight. (Fig. 99) Stand at rest on both feet; give a shove with the left foot so that your right foot goes around in a small circle on the outside edge of the skate. When this circle is finished, a push is given with the right foot, and the left foot makes a circle. **2.** The next step is the figure eight on the inside of the skate.

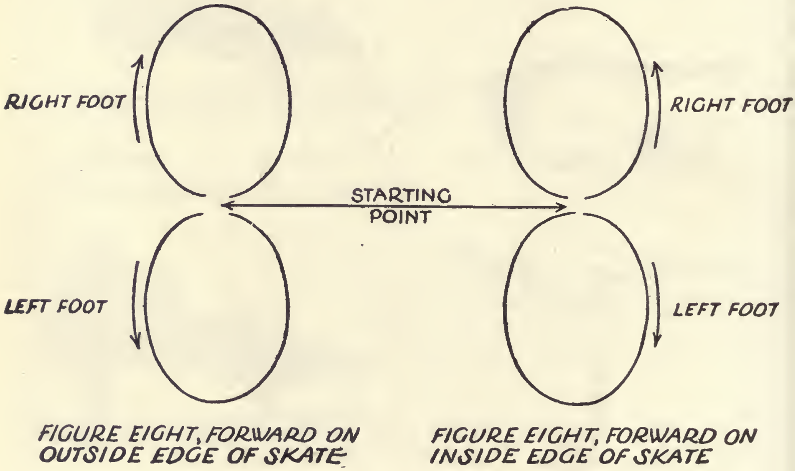

RIGHT FOOT
LEFT FOOT
STARTING POINT
RIGHT FOOT
LEFT FOOT
FIGURE EIGHT, FORWARD ON OUTSIDE EDGE OF SKATE
FIGURE EIGHT, FORWARD ON INSIDE EDGE OF SKATE

Fig. 99. The figure eight.

Project 78 (I). **Learning to do the figure three, or the heart.**

1. After you have learned to do the figure eight, try the figure three. (Fig. 100) It is done like the eight except that when the circle is half finished, the body turns

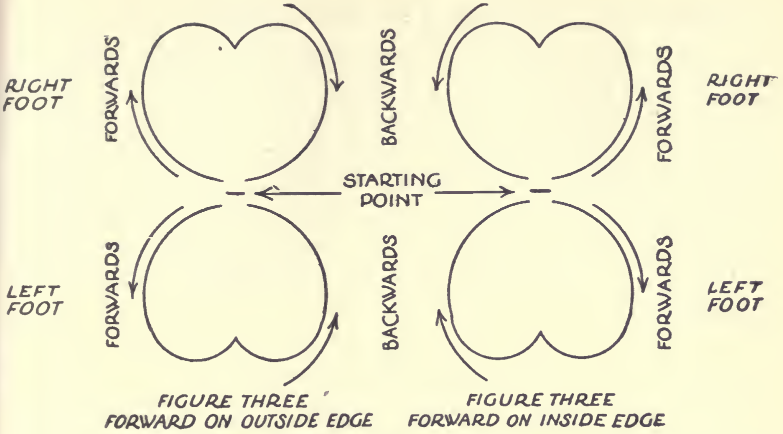

RIGHT FOOT
FORWARDS
BACKWARDS
FORWARDS
RIGHT FOOT
STARTING POINT
LEFT FOOT
FORWARDS
BACKWARDS
FORWARDS
LEFT FOOT
FIGURE THREE FORWARD ON OUTSIDE EDGE
FIGURE THREE FORWARD ON INSIDE EDGE

Fig. 100. The figure three or the heart.

halfway round on the toe of the skate and finishes the last half of the circle going backwards. This figure is also made on both the outside and inside edges.

2. These figures, the eights and the threes, may also be done backwards but are then very difficult.

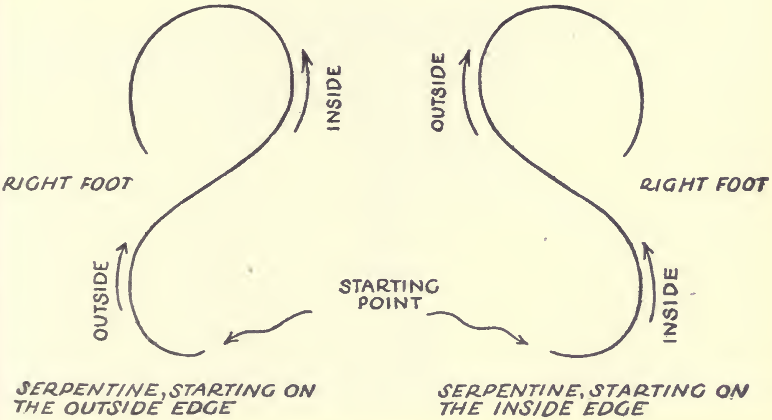

INSIDE
OUTSIDE
RIGHT FOOT
RIGHT FOOT
OUTSIDE
STARTING POINT
INSIDE
SERPENTINE, STARTING ON THE OUTSIDE EDGE
SERPENTINE, STARTING ON THE INSIDE EDGE

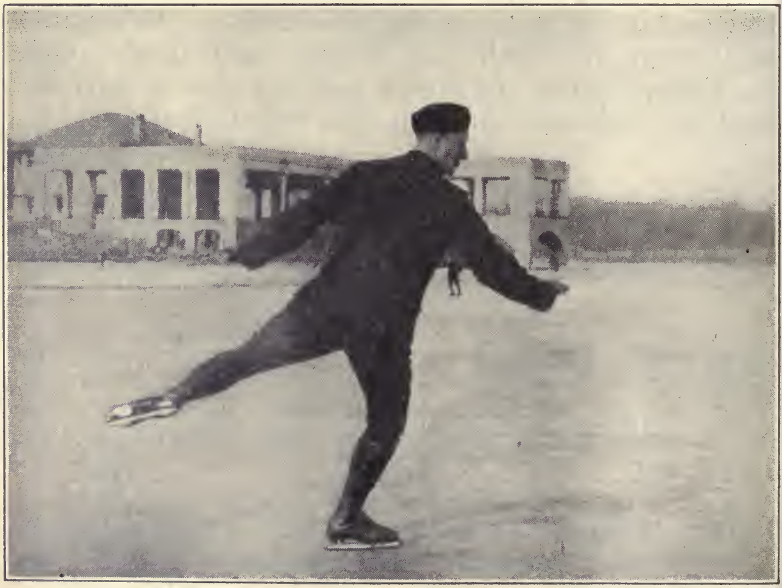
Fig. 101. The serpentine or change of edge.

Project 79 (I). Learning to do the serpentine.

1. Another figure is the serpentine (Fig. 101), or change of edge. A half circle is first made on the outside of the right skate, and then, by a sudden turn of the body and swing of the balance leg, the weight changes over to the inside of the same skate and a whole circle is skated on this edge. **2.** Then the same thing is done on the left. **3.** In the next serpentine, the figure is started on the inside edge and finished on the outside.

Project 80 (I). Improving your skating form.

To be a good skater, one should strive not merely to do a figure but also to do it gracefully. (Fig. 102) Following are some of the rules that will help you to achieve



Courtesy of Fred Hanson

Fig. 102. Good form in skating.

good skating form: *a*. The head should be erect. *b*. The body should be held upright in a straight line with no bend at the hips. *c*. The skating leg should be slightly bent at the knee. *d*. In figure skating, the free leg, or balance leg as it is called, should be carried with the toe pointed down and outwards. *e*. The arms should hang freely, but should not be flourished.

CHAPTER XII

INDOOR WINTER AMUSEMENTS

TOYS

The word *toys* suggests many kinds of simple machines that you like to play with. Many of these toys illustrate scientific principles.

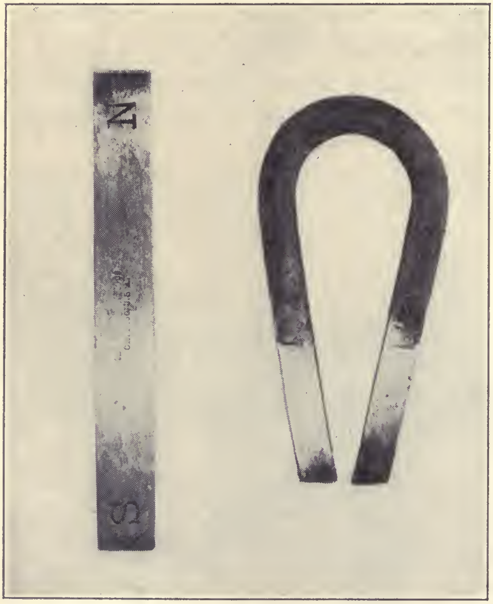


Fig. 103. Bar and horseshoe magnets.

A. MAGNETS

A magnet is a substance that has the power of attracting iron. Some things found outdoors are magnets to start with, and hence are called *natural* magnets. One of the ores from which iron is obtained has been named *magnetite* because it has this magnetic power. Magnets made by man are *artificial* magnets. These are made of steel, either in the form of a horseshoe or as straight bars. (Fig. 103) These magnets are stronger at the ends, which are called *poles* — one the *north* pole, the other the *south* pole.

Project 81 (G). **Learning scientific facts by experimenting with magnets.**

1. For this experiment you will need the following materials: horseshoe magnet, tumbler, penny, nickel, dime, tacks, nail, file, piece of paper, glass, thin board; and for the work suggested in sections 6 and 7, you will need another magnet. **2.** What kinds of substances will a horseshoe magnet pick up? Try a penny, a nickel, a dime, and some tacks or nails. How far can you move a nail with your magnet? How close to the nails must the magnet be placed before the nail is affected by its power? How many tacks in a string can you pick up? **3.** Will a magnet work if you put something thin between it and the tacks? Try a piece of paper, board, glass, and galvanized iron. Do you notice any difference in the effects of these substances?

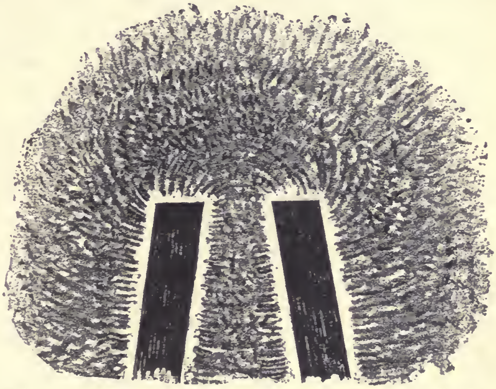


Fig. 104. Iron filings around a horseshoe magnet

4. Make some iron filings by filing some nails. Put a piece of paper over a horseshoe magnet lying on a table, and sprinkle some of the iron filings on this paper. Make a drawing in your science notebook showing the way the filings are arranged. (Fig. 104)

Place the iron bar across the end of the magnet and try the experiment again. **5.** Place a horseshoe magnet on its curved end in a tumbler and support it by stuffing paper around it. It should be so placed that the ends come just level with the ends of the tumbler. Put a piece of paper across the tumbler and sprinkle iron filings on it. What happens? Make a drawing of the filings in your notebook.

6. Place two horseshoe magnets on the table, end to end, about one inch apart, so that the north end of one (that is, the one marked with an *N*) is opposite the north end of the other. Cover them with paper and sprinkle iron filings on the paper. What happens? Make a drawing of the way the filings are arranged in your science notebook. **7.** Now place the north end of one magnet opposite the south end of the other. Cover with paper and sprinkle with filings. Draw. How does the arrangement differ from that in number 6?

8. Try to magnetize the blade of your knife by rubbing it over the magnet. Then see whether you can pick up tacks with the blade. **9.** In order to play magnetic jackstraws get some iron wire and cut it up into pieces about as long as a match. Twist them into different shapes. Then use them like ordinary jackstraws except that you pick them up with a magnet. You can give different values to the various pieces.

B. The Motor

A motor (Fig. 105) is really made up of two magnets. One, called the *field magnet*, is fixed; and the other, called the *armature*, revolves. These are called *electromagnets*, and they have the same properties as ordinary magnets. They are made by winding coils of wire around a core of soft iron. When a current of electricity passes through the wire, the iron core becomes a magnet. Experiments with ordinary magnets show that when the north poles of two magnets are brought near each other, they are pushed apart; and if the two south poles are brought together, the same thing happens. This principle is stated as follows: *Like poles repel.* If the north pole of one magnet is brought near the south pole of another magnet, the two poles are drawn together. This principle is stated as follows: *Unlike poles attract.*

When a dry battery is connected with a motor, the field magnet and armature become magnets; and following the laws of magnets that like poles repel and unlike poles attract, the armature moves, since it is free to revolve on its axis. Hence you can think of a motor as made of two magnets whose poles are attracting and repelling each other with great rapidity.

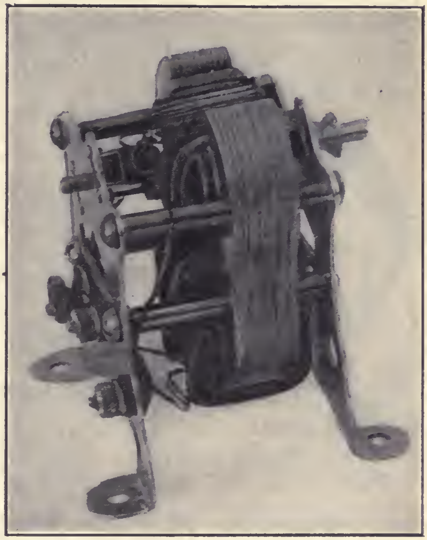


Fig. 105. A toy motor.

Project 82 (G). Learning how the motor works.

1. Connect a toy motor with one dry battery and then with two batteries and see whether you notice any difference in the speed. **2.** Find the following parts: armature, fixed or field magnet, brushes, commutator or split ring. 3. Connect the motor with a dry battery. See whether the field magnet will attract tacks.

C. THE COMPASS

Another property of the magnet, besides this power to attract iron, is its power of pointing north and south. In the early days natural magnets were called *leading stones*, or *lodestones*, because they were used to *lead*, that is, to guide sailors on their voyages. A compass, as it is made to-day, consists of a magnet so mounted on a pivot that it can turn easily. (Fig. 106) Before the compass came into use by sailors, they never dared to sail their ships very far from land for fear of being lost.

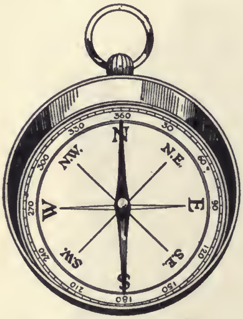


Fig. 106. Compass, which is a magnet free to turn.

Project 83 (G). Studying the action of a compass.

1. You will need to secure a magnet, a knitting needle, two large darning needles, two thin pieces of cork, and a plate. 2. Magnetize a knitting needle by rubbing one end over one pole of the magnet and the other over the other pole. Stroke it several times. 3. Fold a piece of paper about one inch square diagonally. Place the needle in the fold of the paper and suspend the paper by means of a thread. In what position does the needle come to rest? Move the needle and try several times. Does it always come to rest in the same position? Magnetize another knitting needle. Bring first one end and then the other end of

this needle near the suspended needle. What difference do you find in the action of the two ends? **4.** Magnetize a large darning needle by rubbing the point on the north pole of the magnet and the eye on the south pole. Magnetize another needle by rubbing the point on the south pole and the eye on the north pole. Cut two thin pieces of cork from a stopper and float them in a plate filled with water. Place a needle on each cork and allow the corks to come to rest. In what direction does each of the needles point? Do the points of both needles point in the same direction? Explain the results of this experiment.

D. THE KALEIDOSCOPE

Project 84 (G). Noticing how many combinations of color and form you can see in the kaleidoscope.

1. Hold the kaleidoscope up to the light and look through it. **2.** Turn it around and notice how the figures change. Do you ever find any two combinations that are just alike? **3.** How many times in each view does the same combination of figures appear?

How does the kaleidoscope work? Inside of the kaleidoscope are three long narrow mirrors so placed, edge to edge, that they form a triangle when seen from one end. (Fig. 107) At one end are two circular pieces of glass, the outer one of ground glass, separated by about a quarter of an inch. In this space between the two pieces of glass are placed broken pieces of colored glass. The light from these pieces is so reflected several times by the three mirrors that several images are formed. When you have been in a clothing store, perhaps you have noticed the mirrors so placed on opposite walls or sides that a man standing in front can see several images of himself. Or again perhaps you have been in ice cream parlors or restaurants which have mirrors on each side of the room, and you have noticed the large number of images of one object and how the place seems to multiply itself endlessly. The kaleidoscope works on the same principle. You will understand it better if you perform the following experiment:

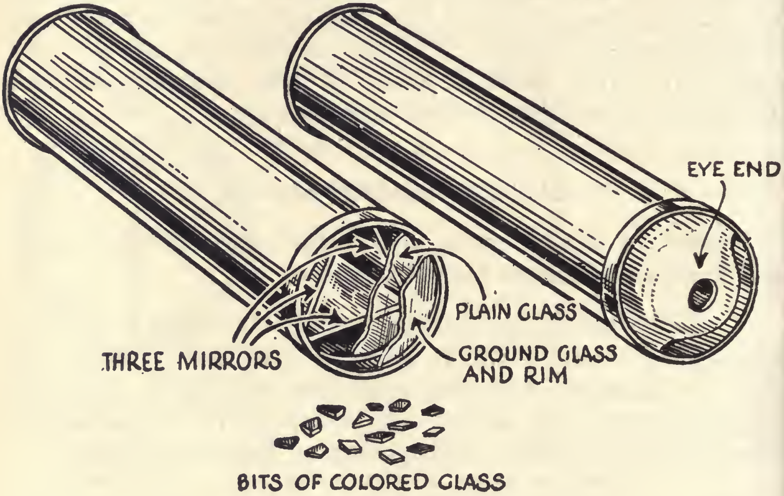


Fig. 107. A kaleidoscope.

Project 85 (G). Noticing how many images of an object can be made by using two mirrors.

1. Get two small hand mirrors of rectangular shape. By means of a rubber band fasten each one to a block so it will stand up on edge. 2. Place the two mirrors

at right angles to each other, their adjacent ends touching. (Fig. 108) Place some small object, such as a button or piece of chalk, about halfway between the mirrors. Or light a short candle that is about half as long as the width of the mirrors. How many images do you see? **3.** Bring the separated ends of the mirror closer together so that the angle they make is smaller. How many images do you see now? **4.** Keep bringing the mirrors closer and closer together and notice the number of images. As you make the angle between the mirrors smaller, how does the number of images formed change?

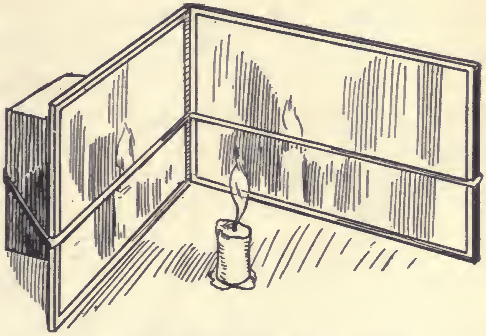


Fig. 108. Experiment with mirrors.

5. On a piece of paper draw a line about six inches long. By means of a protractor draw three lines from one end of this line, making angles of 90 degrees, 60 degrees, and 45 degrees. Place the two mirrors on the lines that make an angle of 90 degrees. Put a piece of chalk between the mirrors and count the number of images. Do the same for 60 degrees and for 45 degrees. Divide 360 by 90, 60, and 45, each in turn. How does the number of images you get in each case compare with the quotient you obtain? **6.** Place the mirrors parallel about six inches apart and put the button or candle between them. How many images do you see? **7.** Make some sort of an irregular drawing on a piece of paper. Place the mirrors with adjacent ends touching over one edge of the drawing. What is the result?

E. The Color Top

Did you ever try to name the colors in a rainbow and to see in what order they came? If you will compare several rainbows, you will find that they have the same colors and that these colors are always placed in the same order, as follows: red, orange, yellow, green, blue, indigo, violet — red being on the outer and violet on the inner edge of the rainbow.

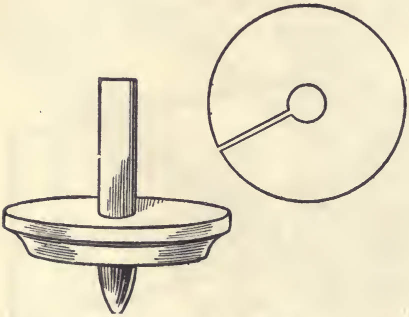


Fig. 109. A color top.

Ordinary sunlight is really made up of many different colors, the same colors that you see in the rainbow. When these colors all work together, the result is ordinary white light. In the case of a rainbow, light passes through raindrops. In so doing, the ray of light is bent, and some colors are bent more than others, causing them to be spread out in the form of a rainbow. In your experiment with the color top you will notice that when you mix two colors, you get a third color, different from either of the first two. In a similar way, when all the colors in the rainbow are mixed, a different color, white, is obtained.

Project 86 (G). Discovering what colors can be made with the color top.

1. The color top is sometimes found in stores. If you do not find one, you can easily make one yourself.

(Fig. 109) Saw off from one end of a spool a piece about a quarter of an inch thick. Whittle out a piece of wood about an inch long so that it will fit tightly in the hole in the spool. Or you can use a pencil. Whittle one end to a point. Push it through the hole so that this end just sticks out about a quarter of an inch. **2.** Now that you have the top made, the next step is to cut the colors to fit it. Secure pieces of paper of as many different rainbow colors as you can find and cut these into circles a little smaller than the spool. In the middle of each cut a hole so that it will fit tightly over the handle of the top. Cut a slit in each circle on one side from the outside edge to the center. (Fig. 109) **3.** Put two differently colored pieces of paper on the handle with the slits so placed that half of each circle shows. Push the pieces down on to the top. To hold the papers in place slip a narrow iron washer over the handle of the top. Spin the top with your finger and notice what color you see. Is it the same as either of the colors with which you started? **4.** Try many different combinations of colors and notice what results you get. Try different ratios of the two colors. Make a record like the following in your notebook:

Colors put on top	Resulting color when top spins

F. THE CAMERA

How is the camera made? (Fig. 110) The camera consists of a *lens* which focuses light, that is, brings it to a point, upon a film placed in a dark box. In front of the lens is a hole, called the *diaphragm*, through which the light passes. The size of this hole can be changed by turning a little lever. Connected with the lens is a *shutter* which opens and closes the hole. This shutter can be set so as to vary the time that the hole is left open. Sometimes the lever is pushed twice, once to open the hole and again to close it. The shutter may also be set so that pushing it once both opens and closes it.

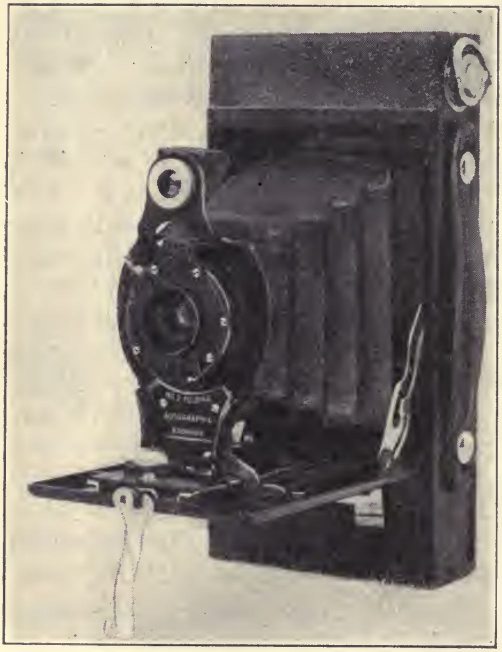


Fig. 110. A folding camera.

How is the camera used to take pictures? When taking a picture, one first sets the lens for the right distance. The diaphragm is set for the proper size; the shutter is set at the proper place; and then the lever is pushed, while the camera is held steady. The size of the diaphragm used and the time allowed for exposure depend on the light that the object receives. The brighter the day, the smaller the hole is made, or the less the time that is allowed for exposure. More time is needed for pictures taken indoors than for those taken outdoors; more time on a cloudy day than on a bright day; more time in the early morning and late evening than in the middle of the day; and more time for a small hole in the diaphragm than for a large hole.

Most cameras use rolls of film that may be put into the camera in daylight. After one picture is taken, the film is rolled around part way until the next figure appears through a piece of red glass in the back. Then another picture is taken and the film turned again, and so on until all of the film is used. It is then removed from the camera and developed.

How are films developed? When the photographer develops a film, he first puts it in a solution called the *developer*, which brings out the picture on the film. Next he puts it into the fixing solution, called *hypo*, and finally he washes it in water and dries it.

How are prints made? To print a picture, a piece of printing paper is placed against the developed film and exposed to light. This piece of paper is then treated in about the same way as was the film; first it is placed in the developer, then in hypo, and then washed and dried.

Whether a picture turns out well or not depends partly on whether the exposure was properly made, and partly on how well it is developed. If a mistake is made in taking the picture, not even the best photographer can develop it so as to get good results.

Project 87 (G). Making a pin-hole camera.

1. Secure a pasteboard box, such as a shoe box. Remove the cover. From one end cut out a piece from two to three inches square. Over this hole glue a piece of thin typewriting paper. In the middle of the other end of the box, by means of a pencil punch a small hole about one eighth of an inch in diameter. (Fig. 111) Put on the cover. **2.** Hold the box up with the hole pointing toward a window. Place your head near the other end and cover your head and end of the box with a jacket or other piece of clothing. What do you see on the paper? How does this image differ from the window itself?

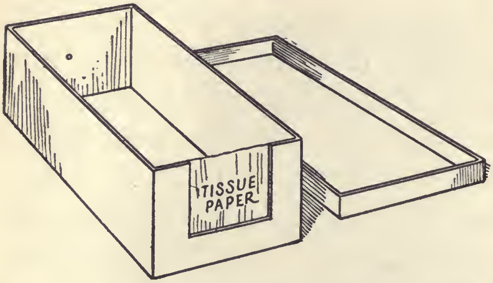


Fig. 111. A pin-hole camera made from a shoe box.

Project 88 (G). Observing how a camera is made.

1. Perhaps someone in the class has a camera that he will bring to school. **2.** Find the following parts: lens, diaphragm, shutter, focusing screw, place for inserting the film. **3.** Notice how the size of the diaphragm can be changed. **4.** Examine the shutter carefully and see how it works. What do the figures and letters mean? **5.** Let someone who knows how put a film in the camera and take a picture of the room, explaining meanwhile what must be done to take the picture. **6.** In order to illustrate the use of the lens, hold up a reading glass and a piece of paper on the side of the glass away from the window. Move the glass back and forth until a clear image is formed on the paper. How does this image differ from the window?

G. The Airplane

Many uses are being made of airplanes, such as to carry mail, to transport passengers, to deliver express packages, to spray insect-infected fields, to patrol forests to watch for forest fires, to take photographs, and to make maps of land. Airships and airplanes have both crossed the Atlantic Ocean. They travel at a tremendous speed. It was reported by the newspapers in 1925 that an American had flown at the rate of 303 miles per hour, or over five miles per minute.

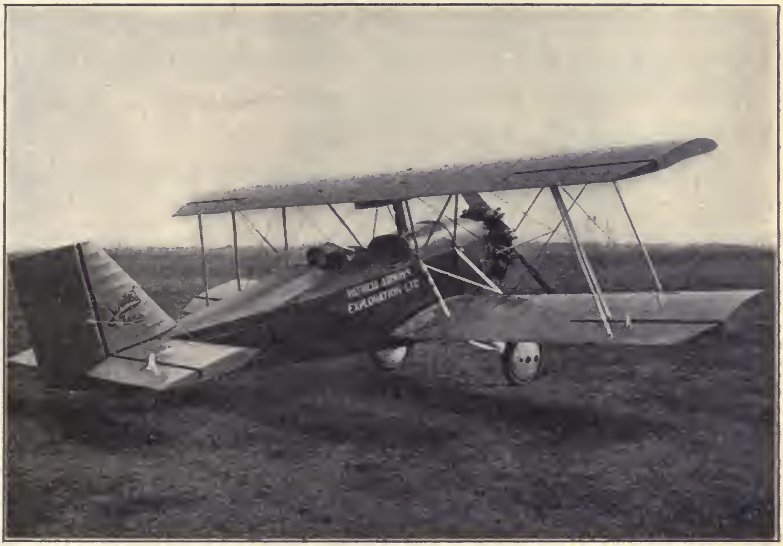


Photo from Ewing Galloway, N. Y.

Fig. 112. A modern biplane, used as a passenger plane for taxi and cross-country flying.

Have you ever wondered what makes an airplane stay up in the air? The wings of a plane are like the covering of the kite. In order to fly a kite, the wind must be blowing; but the airplane makes its own wind, driving itself ahead at tremendous speed by propellers which are made to rotate by a gas engine. Just as the wind blows on the kite and bears it up, so the wind made by the motion of the airplane bears up the wings of the airplane and keeps it in the air. The plane must keep in motion in order to stay in the air. As soon as it stops going ahead, it falls to the ground.

A pilot steers the plane by means of rudders — one set for steering from side to side, and another for up and down. When starting the machine, a certain speed must be attained before it will leave the ground. The airplane is mounted on wheels, and a start is given on level ground by means of the propeller. Two types of airplane are used — the monoplane and the biplane. (See Fig. 112)

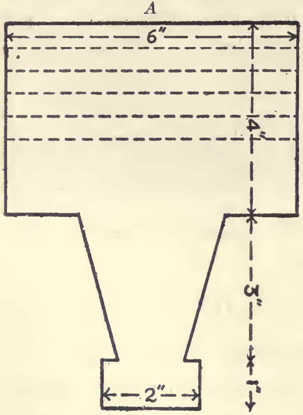


Fig. 113. Paper glider.

Project 89 (1). Making a paper glider. (Fig. 113)

1. Get some stiff writing paper and cut out a piece eight inches long and six inches wide. **2.** Fold it through the middle lengthwise and cut it out like Figure 113. **3.** Unfold it and fold over at the edge *A* a strip one half inch wide. Fold this over again four times.

4. Hold the glider above the head or stand on a chair and give it a gentle shove. How far does it go before touching the floor? **5.** Make another glider, but do not fold over the edge. What difference do you note in the motions of the two? **6.** If the glider does not work well, you may need to make some little changes. Its success depends on the proper adjustment of three things: (1) the weight at the leading edge, (2) the size of the tail, and (3) the angle that the two halves make with each other.

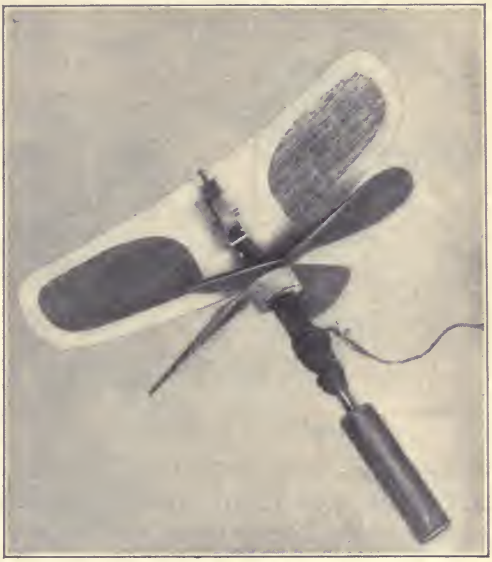


Fig. 114. Toy airplane.

Project 90 (G). Observing how a toy airplane works. (Fig. 114)

1. Fly a toy airplane according to the directions that come with it and see how it works. **2.** How long does it stay in the air? **3.** How far does it go? **4.** How high does it go? **5.** Why doesn't it stay up any longer?

H. THE GYROSCOPE

Project 91 (G). Discovering in what peculiar ways the gyroscope can be made to spin.

1. Place one end of a string through the hole in the axis and wind up the string on this axis by turning the wheel. To unwind, hold the frame in the left hand and pull the string steadily and rapidly with the right hand. Wind it up for each of the following experiments. **2.** Let the top spin on the table, placing the frame in several positions. **3.** Balance the spinning top on the edge of a glass tumbler. **4.** Hold the top on the tip of a finger. **5.** Put a box over the top and allow it to spin on the table. **6.** Place the top on the stand at various angles, once at right angles.

7. Start the top spinning on the table so that the axis is horizontal. Then make a loop of the string, pass it around one end of the axis, and lift the top from the table. (Fig. 115) **8.** While two children hold a string tightly between them so that the string slopes, let a third child put the spinning top on the higher end of the string.

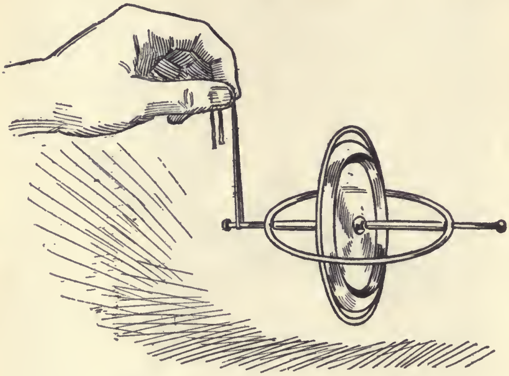


Fig. 115. Toy gyroscope.

9. Perhaps you occasionally take your bicycle apart and fix it. Some time when you have one of the wheels and its axle separated from the remainder of the bicycle, place one end of the axle on a table edge or platform edge, the other end of the axle supported by your finger. Whirl the wheel in this position rapidly, then lift it with your finger still under the one end of the axle. What happens? Why?

Of what use is the gyroscope? The *gyroscope,* besides being an interesting toy, has several practical uses.

One is to take the place of a compass in steering ships. This gyrocompass is kept rotating in an exact north-and-south plane by means of a motor. The compass is floated in a liquor called mercury, so that, no matter in what way the ship turns, this compass always moves in this north-and-south plane, thus taking the place of the needle in the compass. (Fig. 116)

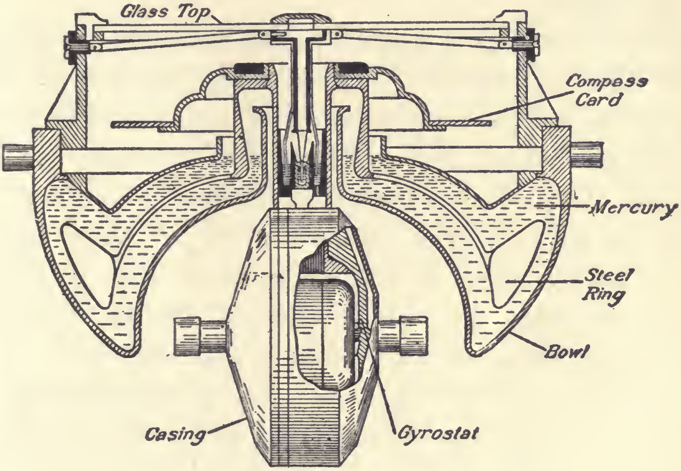


Fig. 116. Section of gyrocompass.

Experiments have been tried with large gyroscopes in ships to see whether they would not prevent the pitching of the ship. So far, however, they have not been found to be of much practical use for this purpose. One man has invented a railroad car that runs on one rail, called the mono-rail car. The car is kept upright by means of a large, rapidly rotating gyroscope.

Why does the gyroscope stay in such unusual positions? Perhaps the most remarkable experiment that you performed with the gyroscope was the one in which it stayed horizontal when held up by a string at one end. What makes the top stay in this position? The explanation has something to do with the motion of the top, because as soon as the top stops spinning, it falls to the table.

Many years ago a great English scientist, named Sir Isaac Newton, studied very carefully the laws of moving bodies, and, as a result of these studies, made certain statements which have been called *Newton's laws of motion*. One of these laws is as follows: A body at rest tends to stay at rest unless moved by some outside force; and a body in motion tends to stay in motion unless stopped by some outside force. You will notice that there are two parts to this law.

The first part of the law is easy to understand. If a body is at rest, we know that it will stay at rest until something moves it.

The second part of the law is more difficult to understand. It says that when the body is once put in motion, it keeps moving unless something stops it. When you start things moving by some action, such as throwing a ball or spinning a top, they soon stop. This is true with all the common things that you can think of, such as the automobile and the locomotive. Unless some power is constantly applied to these machines to keep them moving, they stop. In each of these cases, however, there is some force that interferes with the motion and makes it stop. One force that is acting constantly on everything is the attraction of the earth, called *gravity*.

When you throw a ball into the air, the force that you put into it is soon overcome by the force of gravity, and the ball falls to the ground. Another force that helps to overcome the motion of the ball is the resistance of the air. This resistance is very noticeable with bodies that are traveling at great speed, such as automobiles and locomotives. When you are riding in an automobile, you can feel the force of this air blowing against you. If it were possible to do away with the force of gravity and the resistance of the air and all other forces acting on the ball, and you should then throw the ball, it would keep on moving forever.

The motions of the earth and other heavenly bodies are illustrations of this law. The earth is rotating very rapidly on its axis once every day; and, as a result of this rotation, we get day and night. What keeps the earth moving? Having once been given this motion, the earth, air and all, keeps on rotating because there is nothing to stop it. This motion has been going on for many, many years in the past and will continue to keep on in the future for an indefinite time unless something stops it. It cannot stop of itself any more than it could start of itself if it were quiet.

Now let us apply this explanation to the gyroscope. When this is set spinning rapidly, it keeps on spinning for a short time in the same plane in which it first starts, regardless of the force of gravity. After a while, when it gets to rotating more slowly, the force of gravity overcomes the force of the rotating top, and it falls to the table. At first, however, the top will spin in a horizontal position even when supported at only one end, because this rotating force is for the time being greater than the force of gravity.

Project 92 (G). Illustrating the motions of the earth by means of a top.

1. The earth has at least three distinct motions, and each of these may be illustrated by means of a common peg top. **2.** Spin the top in the ordinary way. This represents the rotation of the earth on its axis, which gives us day and night. **3.** Spin the top again. Now push against the upper end of the top with a pencil. The free end of the axis now moves around in a small circle by itself. The axis of the earth moves in a similar way, and this motion is called *precession.* As a result of this motion the points in the heavens to which the earth's axis points are slowly changing, so that in thousands of years from now what is now known as the North Star will no longer be the North Star. **4.** Spin the top on a dinner plate and tilt the plate in such a way that the top will run around the outer edge. This motion corresponds to the motion of the earth around the sun, which gives us the change in seasons. **5.** Spin the top again in the plate in such a way as to give it these three motions all at the same time. **6.** Can you explain why we don't feel these different motions of the earth? What have you ever observed that gave any proof that the earth is moving? See whether you can find out whether the earth has any other motions.

I. TILLY TINKER, THE BALANCING QUEEN

Project 93 (G). Discovering how many kinds of dances Tilly Tinker will perform. (Fig. 117)

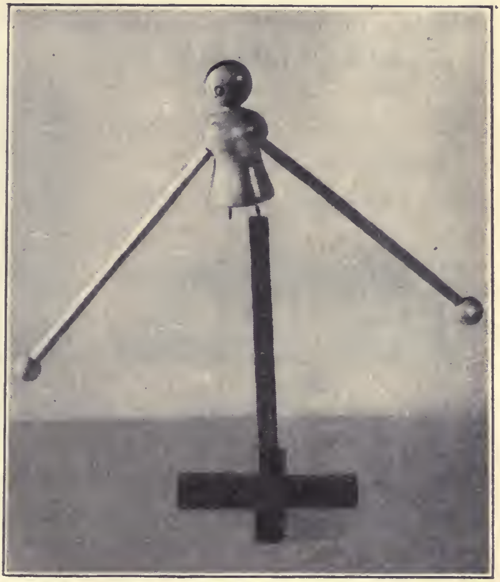


Fig. 117. Tilly Tinker, the balancing queen.

1. Put the parts together, following the directions that come with the outfit. If you have not this particular toy, use any balancing doll, or animal, and adapt the following directions. **2.** *The forward dip.* Hold Tilly forward until she is at right angles to the standard, and then let go. **3.** *The side step.* Hold Tilly over to one side until the arm touches the standard, and then let go. **4.** *Combination dip and side step.* Hold Tilly forward as in the forward dip and turn her partly around so that the arms are halfway between a vertical and a horizontal position, and then let go. **5.** *The whirl.* With Tilly in an upright position, twirl her gently, using the thumb and forefinger. Try again, but turn with much greater speed. What differences do you notice in the way she spins? Spin her again, first dipping the figure forward about halfway before spinning. What different motions does she make now? **6.** *The dipping whirl.* Push one of the arms over until it nearly touches the standard; then give it a strong circular push.

What scientific principles does Tilly illustrate? Tilly is an application of the principles of *balance,* or *equilibrium,* as the textbooks on physics call it. Three kinds of equilibrium are commonly mentioned: *stable, unstable,* and *neutral.* (Fig. 118) An object is said to be in stable equilibrium when it is hard to make it tip over; a book lying flat on the table is in stable equilibrium. Unstable equilibrium exists when an object can be tipped over easily; a book standing on its edge is in unstable equilibrium. An object is in neutral equilibrium if, when it is moved, the equilibrium remains the same; for example, a ball rolling along the floor is in neutral equilibrium. Which of these three types does Tilly illustrate?

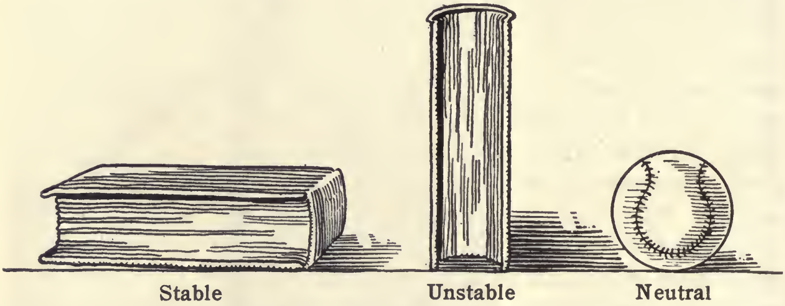


Fig. 118. Kinds of balance, or equilibrium.

Perhaps you wonder why some bodies are in stable and others in unstable balance. There is a point in every body known as the center of gravity. This is a point so situated that we can imagine all the weight of an object to be placed at this one point. Think of a book lying on the table. If we could imagine a very tiny object smaller than the head of a pin to weigh as much as the book, and if this were placed at the center of gravity, then this weight would act the same as the weight of the whole book; or, to put it in other words, the center of gravity of an object is the point on which the entire weight of the object may be said to be placed. In the case of an object of regular shape, like a ball, this point is in the center of the ball; in the case of a book, it would be the middle point within the book. We will call this point the center of gravity. Sometimes this center may be the outside of the object. For example, in Tilly Tinker it is below the point where she balances on the standard. When this center is kept below the point of support for the object, the equilibrium is stable. The heavy weights keep the center of gravity so low that it is nearly always below the point of support — that is, Tilly's toe.

Why doesn't Tilly Tinker fall off of the standard? You have made Tilly do all sorts of peculiar motions, and yet she doesn't fall over. You have noticed that at the end of each arm is a heavy iron ball. If you will take the arms out and hold them in one hand and hold Tilly in the other, you will find that these weights are heavier than Tilly. Why were the arms made so long? If the arms were shorter, Tilly would not stay on her pedestal. The purpose of the long arms with the weights at the end is to get the center of gravity below the point where Tilly's toes balance on the standard.

Project 94 (G). Performing experiments to illustrate the laws of balance.

1. For this experiment, you will need two forks, a cork stopper, and a pencil about three inches long. Stick the prongs of two forks into opposite sides of the cork as shown in Figure 119. **2.** Place the sharpened end of the pencil under the center of the cork. Hold the other end of the pencil in the fingers so that the forks will not touch the hand. The whole thing will balance because the center of gravity is below the tip of the pencil. **3.** Punch a hole in each end of an egg and blow out the contents. Pour into the eggshell about a teaspoonful of shot. Melt some paraffin and close up the holes in the shell. The egg will now stay in whatever position you put it because the shot makes the center of gravity low. **4.** Blow out the contents of another egg and put in a teaspoonful of shot. Also add a little powdered sealing wax. Now heat the shell till the sealing wax melts. Allow it to cool. The shot will now be held in one position by the wax. Notice the difference in the way the two eggs behave in varying positions. Can you explain this difference? In place of paraffin sealing wax may be used to close up the holes in the eggshell. **5.** What articles on your dinner table illustrate stable balance? What articles illustrate unstable balance?

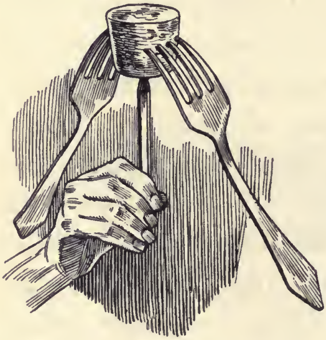


Fig. 119. Balancing forks.

EXPERIMENTS TO ENTERTAIN FRIENDS

In this part of the chapter you will be told how to perform some interesting experiments that you may like to use to entertain your parents and friends. Do the experiments first in school with the class, so that you will understand just how they are done. Then you might give an entertainment to the rest of the school and perform the experiments before them. Or you may perform them some evening at home for the benefit of your family.

A. Surface Tension of Water

Project 95 (G). Making a needle float on water.

1. Although a needle is seven times heavier than water, it can be made to float if the experiment is carefully done. **2.** Take a small needle between the finger and thumb, and holding your hand as near to the water as you can without touching it, gently drop the needle. **3.** Another way to perform this experiment is to put a small piece of tissue paper on the water and put the needle on the paper. Then carefully remove the paper by pushing it down under water. **4.** Still another way: Make a crease in a small strip of paper by folding it. Put the needle in this crease and then gently push the paper under water with the fingers. **5.** Magnetize the needle by rubbing it over a magnet. In what direction does it point while floating. Now you have a simple compass. **6.** Fill a tumbler full of water. Set it on the table and carefully add water, a few drops at a time, till the water runs over. Notice that the water can be made to rise in a curved surface above the level of the edge of the tumbler before it runs over. This experiment illustrates the same thing as does the one with the floating needle, namely, the surface tension of water.

Why does the needle float? The needle floats on account of what is called the *surface tension* of water. The particles of water at the surface have no water above them. As a result these particles of water at the surface are drawn together in such a way that they act like a thin rubber membrane stretched over the surface. Light objects will lie upon this without breaking through. The insect known as the water strider walks on top of the water on this surface film. (See page 93.)

B. Chemical Experiments

Several curious experiments may be performed by making use of the fact that when *ammonia* and *hydrochloric acid* are brought near together, a white cloud forms. These substances are both invisible gases which are kept dissolved in water. When the liquids are brought near together, some of each gas is given off and these gases unite to form the white cloud.

Project 96 (G). Performing some magical chemical experiments.

1. For these two experiments you will need a tumbler, a saucer, some ammonia, and some hydrochloric acid. The ammonia can be obtained from the kitchen at home and the acid bought at the drug store at slight expense. **2.** Put a few drops of ammonia water in a tumbler, and a drop or two of hydrochloric acid on a saucer. **3.** Invert the saucer over the tumbler and cover with a handkerchief. **4.** Allow to stand for half a minute and then remove the handkerchief. The tumbler will be found full of a dense cloud. **5.** For the second experiment secure a picture of someone smoking a cigar, cigarette, or a pipe. **6.** Put a drop of the hydrochloric acid on the end of the cigar or pipe out of which the smoke would naturally come. Dip a cloth in ammonia water and bring the cloth near the picture. The pipe or cigar will begin to smoke. **7.** Get two clay pipes. Fill the bowl of each with absorbent cotton. Pour a few drops of ammonia on the cotton in one bowl and a few drops of hydrochloric acid on the cotton in the other bowl. Bring the two bowls close together. What happens? Place the mouths of the bowls tight together, one over the other. Blow through the stem of one of the pipes. Do not draw back through the pipes so as to breathe in any of the gas.

Project 97 (I). Testing some common substances of the kitchen with litmus paper.

1. Get some *litmus paper*, both red and blue, from a drug store. Substances that turn red litmus paper blue are called *alkaline*, while those that turn blue litmus red are called *acid*, and those which do not turn either are called *neutral*. If the paper you bought is red, turn some of it blue by dipping it in ammonia. If the paper is blue, turn some of it red by dipping it in vinegar. **2.** Now that you are provided with the two kinds of litmus paper, try out a great many substances that you can find around the kitchen to see whether they are acid, alkaline, or neutral. Following are some substances that you can test: orange, lemon, any fresh fruit, tomatoes, limewater, tea, coffee, sweet milk, sour milk, butter milk, baking soda, cream of tartar, baking powder, washing soda, soap, vinegar, ammonia. The powders should first be dissolved in water. Use the juices of fruits and vegetables. **3.** Test each substance with both blue and red litmus paper. Then, according to the results you get, write the names of the substances in the proper columns in your notebook.

Acid	Alkaline	Neutral

C. Frictional Electricity

We commonly speak of two kinds of electricity — *current* electricity and *frictional* electricity. The current electricity is the kind that passes over wires and is used for lighting, and that which comes from a dry battery when you run a toy motor. Frictional electricity is the kind that is caused by friction or rubbing. It has been found that when certain substances are rubbed together, electricity is produced; for example, when silk is rubbed on glass and when flannel is rubbed on hard rubber. Perhaps you have noticed during cold weather when you are combing your hair that sometimes the hairs are drawn to the comb. This motion occurs because electricity has been made by rubbing the comb over the hair. Again, after you have scuffed your feet along a carpet and then touched your finger to a person or a radiator, you may have seen a little spark pass from your finger. This electricity was made by the friction of your feet on the carpet.

There are two kinds of frictional electricity, *positive* and *negative*. You remember that you learned while studying magnets that like poles repel and unlike attract. Here we have a similar law, namely, that like charges of electricity repel each other and unlike charges attract each other. That law will help you to understand some of the strange happenings in the experiments you are to perform.

Project 98 (G). Performing some experiments with frictional electricity.

1. *The magic arrow.* Put the eye of a needle in a small piece of cork. Cut out a paper arrow like that in Figure 120 and balance it on top of the needle. Invert a tumbler over the needle. Announce to the company that you will make the arrow point to any person in the room without touching it. Take a piece of silk and rub briskly on the side of the tumbler next to the person named. What happens?

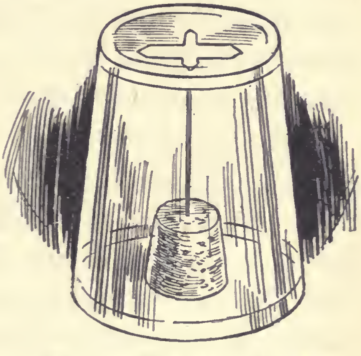


Fig. 120. The magic arrow.

2. *The dancing dolls.* Cut from tissue paper some small dolls one inch or less in length. Lay them on the table. On each side place a book and then support a piece of glass on the upper edges of the books. Rub the glass directly over the dolls with a piece of silk and notice the action of the dolls. Try different thicknesses of books to see which gives the best results.

Explanation of the experiment. When you rubbed silk on glass in your experiments, positive electricity was made, which attracted the negative electricity on the arrow. Although the silk did not touch the arrow, electricity passed from the silk through the air to the arrow. In the case of the dancing dolls, sometimes unlike charges of electricity came together, and as a result the dolls were attracted to the glass; at other times like charges of electricity came together, and as a result the dolls were repelled.

What is lightning? Lightning is an example on a large scale of frictional electricity in nature. This electricity gathers on the clouds or on the earth and may pass from one cloud to another or from a cloud to the earth as a stroke of lightning. Read the paragraph about Franklin's kite on page 254. So-called heat lightning is ordinary lightning seen a long way off.

Lightning sometimes plays very curious tricks. Once the author was struck by lightning while walking across the White Mountains in New Hampshire. The lightning took the nails from the soles of his shoes so that the sole flapped free from the rest of the shoe, making it necessary to tie the sole on with a string. The lightning struck another member of his party on the head and took off the hair from a small round spot as smoothly as it could be done with a razor.

To find how far away the lightning is, count the number of seconds from the time when you see the lightning to the time when you hear the thunder. Light travels almost instantaneously, while sound travels much more slowly, at about the rate of a mile in five seconds. If you divide the number of seconds that you counted by five, the quotient will be the distance away from you in miles that the lightning struck.

D. The Weight of Air

A little explanation about the weight of air will help you better to understand the experiments that you are to perform. Air is so light that it is difficult to realize that it is a real substance and has weight. However, on a very windy day you find that air exerts a great pressure; you know that even trees and houses may be blown down by the wind, which is simply air in motion.

Why don't we feel the weight of air pressing down on our hands? If you should take a quart of air and weigh it, you would find it very light indeed; but when you think of all the air there is around us and above us, there is so much of it that all together it weighs a great deal. Experiments have shown that the weight of the air that bears down on each square inch is about fifteen pounds. (Fig. 121) If you will look at your hand, you will see that there is an area there of ten or fifteen square inches; hence the total weight of air bearing down on your hand is between 150 and 200 pounds. You will ask at once how this can be true since you do not feel any weight at all. The reason you do not feel the weight of the air is because the air is also pressing *up* on the under side of your hand with the

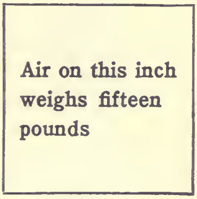


Fig. 121

same force; hence the two pressures balance each other. You are so accustomed to thinking of objects as pressing *down* that it may seem odd at first to think of air as pressing *up*. Air is a gas, and it is a law of all gases that the pressure in every direction, up, down, and sideways, is the same.

How does the pump work? One application of the pressure of air is found in the ordinary *lift* pump. (Fig. 122) Something forces the water from the well or cistern up through the pipe and out of the pump. This something is the weight of the air bearing down on the surface of the water in the well. The pump is a machine which removes the air from the pipe; so the water in the pipe is forced up by the air pressure on the water in the well. There is a limit to the weight of the air and therefore to the height to which water can be forced by the ordinary pump. The weight of air on the water is enough to force it up to a height of about 30 feet. For pumping water higher than this distance the *force* pump is used.

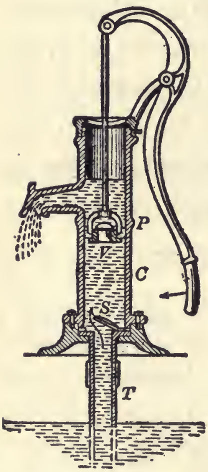


Fig. 122. A cistern pump.

Other common illustrations of the weight of air are seen in the use of straws for drinking soda and in the use of medicine droppers for filling fountain pens; or in the case of self-filling pens, the rubber inside takes the place of the medicine dropper. Explain all these.

Project 99 (G). Showing by experiments that air has weight.

1. Fill a bottle full of water. Put a piece of paper over the top and invert the bottle in a dish of water. After the mouth of the bottle is under water, remove the paper. Why does the water stay up in the bottle?

2. Put a penny in a plate. Add water to cover the penny. Announce to your friends that you will remove the penny with your finger without wetting the finger. Stick two short matches in a cork, with the phosphorus end up. Float the cork on the water in the plate a little to one side of the penny. Light the matches and invert a tumbler over them. In a short time the water rises in the tumbler leaving the penny uncovered. You may need to do the experiment a couple of times in order to find out just how much water to put in the plate in the first place. Can you explain why the water rises in the tumbler?

3. Fill a tumbler full of water. Take a piece of paper a little larger than the tumbler and press it down firmly on the top of the tumbler. It is necessary that the paper shall touch the rim of the tumbler all the way around. With one hand press down on the paper; with the other hand take hold of the tumbler and invert it. Then remove the hand that is holding the paper. (Fig. 123) What

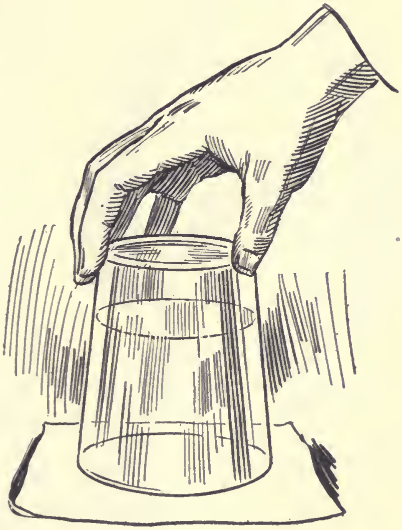


Fig. 123. Water held in tumbler by air pressure.

makes the paper stay on the tumbler? **4.** If you wish, you can do the experiment in such a way as to make a mysterious trick of it. Cut a piece of mica in a circular form of just the right size to fit the mouth of the tumbler. Hold the mica in the palm of your hand and cautiously transfer it from your palm to the top of the tumbler. Then turn the tumbler upside down. The mica is so transparent that it cannot be easily seen, and hence it will look as though the water were kept in the tumbler without support.

5. Boil an egg hard and then remove the shell. Get either a pint or quart milk bottle. Light a piece of paper and thrust it gently into the bottle. As soon as the flame goes out, place the egg on the mouth of the bottle. (Fig. 124) Allow it to stand for an hour and notice what happens. Or put about an inch of water in the bottle and heat it gradually so as not to crack the bottle. After the water boils for a few minutes, remove the bottle from the heat and place the egg on the mouth of the bottle.

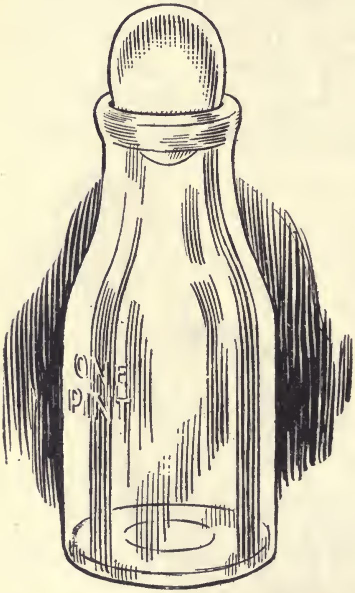


Fig. 124. Egg in milk bottle. Experiment illustrating air pressure.

6. Get a piece of rubber tubing about two feet long and two pans, one filled with water. Place the empty pan a little lower than the other pan. Place the rubber tube in the pan of water. After the air bubbles have all come out, pinch one end of the tube tightly between the thumb and finger and bring the end out, over, and down to the empty lower pan. What makes the water keep running? This tube is called a *siphon.* Keep the end of the tube in the second pan under water. Then lift this pan higher than the first pan. What happens?

7. To make a leather sucker get a piece of soft leather with one side very smooth. Cut out a circle two or three inches in diameter. Through the center pass a piece of strong string and tie a knot to prevent the string from pulling through. In order to lift some object, such as a smooth block of wood, soak the leather in water till it becomes soft and pliable and then apply it firmly to the surface of the object you want to lift.

E. THE MAGIC PENNY

Project 100 (I). Making a penny appear and then disappear without touching it.

1. For this experiment you will need a tin pan (three or four inches deep and eight or nine inches in diameter), a penny, and a piece of rubber tubing about two feet long. If you cannot get tubing, you can do part number 2 without it. **2.** Put the tin pan on a table. Place a penny near the middle of the bottom of the pan. Ask someone to sit about two feet away

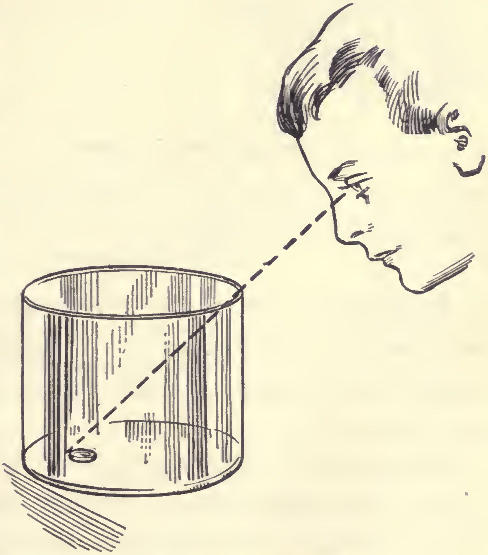


Fig. 125. The appearing penny.

from the pan and hold the head in such a position that the penny is just out of sight, hidden by the side of the pan. (Fig. 125) Now announce that you are going to make the penny appear without touching it. Add water to the pan and the penny will become visible. **3.** Now announce that you will make the penny disappear. Place the rubber tubing under water. Pinch one end of the tubing tightly and bring it out of the water, and, holding it over a pan placed below the table in a chair, let go. (Fig. 126) The water will begin to siphon out, and the penny will disappear from view.

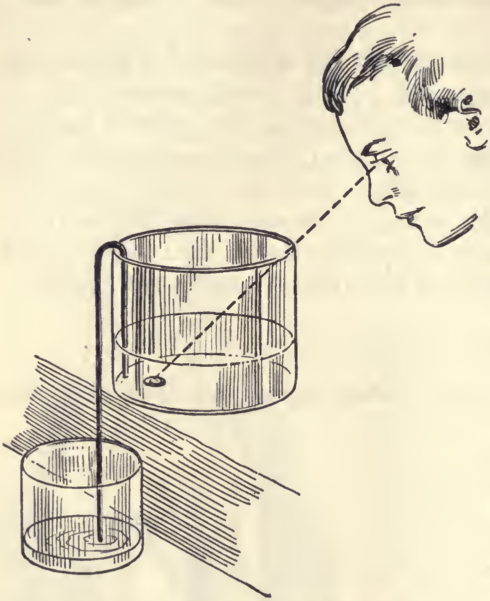


Fig. 126. The disappearing penny.

Explanation of the experiment. In Figure 127 *AB* represents a vertical section through the pan, *E* the eye, and *P* the penny, so placed that it cannot be seen by the eye at *E*.

Now look at Figure 128. In this figure *CD* represents the water line. When light passes from the penny *P* to the surface of the water at *G*, it does not pass out in the straight line *PGJ*, but it is bent in direction so that it passes along the line *PGAE*, and thus the coin can be seen by the eye. To the eye it seems as though the coin were at the point *H*, at the end of the straight line, *GH*.

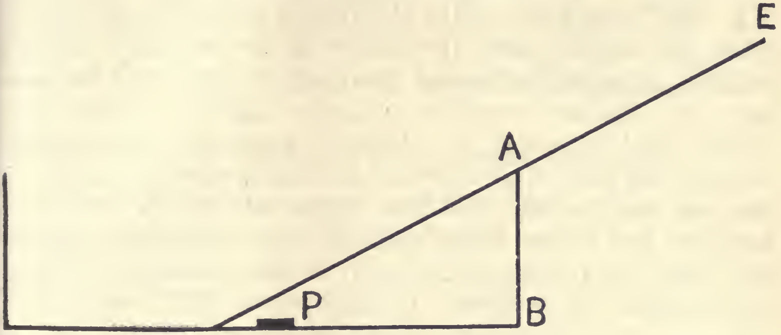


Fig. 127. Drawing to explain the magic penny.

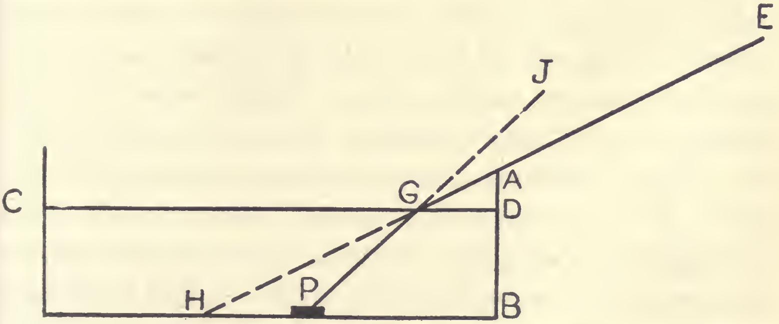


Fig. 128. Drawing to explain the magic penny.

In the last part of the experiment this process is reversed. You start with the coin visible as in Figure 128; and as the water is removed, the coin becomes invisible as in Figure 127.

F. EXPERIMENTS WITH ICE

Project 101 (G). **Making water boil by using ice.**

1. Fill a flask or bottle about one third full of water. Heat the water until it boils. If an ordinary bottle is used, it must be heated gradually to prevent breaking. **2.** Put in a rubber stopper tightly, invert the bottle, and support it. Pound some ice into small pieces, and pour a mixture of ice and water on the bottom of the bottle. What happens to the water? **3.** After the water stops boiling, pour it out into a dish and take its temperature with a thermometer. How much below the ordinary boiling point (212°) is it?

Explanation of the experiment. In order to understand this experiment you need two facts: 1. When steam is cooled it condenses into water, and as a result the pressure of the air is lessened. When the water boiled, the space in the bottle was filled with steam. When ice was put on the bottle, the steam condensed, and the pressure on the water became less. 2. The boiling point of water depends on the pressure of the air. Under ordinary pressure water boils at 212 degrees; if the pressure is lessened, boiling takes place at a lower temperature. Hence, in this experiment, as the pressure in the bottle lessened, the boiling point was lowered; and the water continued to boil although the temperature of the water was cooled below the ordinary boiling point.

Perhaps you have read that on very high mountains it is difficult to cook eggs by boiling. The explanation is similar to that given in this experiment. The pressure of the air is less at the top of the mountain than at its base; therefore the boiling point of water is lowered. If the mountain were high enough, the temperature at which water boils might be so low that, even if the water boiled, the eggs would not be cooked.

Project 102 (G). Making a tin cup freeze to a board.

1. Fill a tin cup about one third full of cracked ice mixed with salt. **2.** Pour a little water on a small piece of board. Press the cup down firmly in this water and allow it to stand. Occasionally stir the ice. In a little while the cup will be frozen to the board. Put a thermometer in the ice and take the temperature.

Explanation of the experiment. The principle applied here is the one used in freezing ice cream; namely, that a mixture of salt and ice reduces the temperature of objects around it more than does ice alone. When salt is mixed with ice, the ice melts. It requires heat to change ice to water; when ice melts, then, heat is taken from the surrounding bodies, and the temperature falls. In this experiment, heat was taken from the water next to the bottom of the dish until it became cold enough to freeze. This principle applies also to large bodies of water, such as ponds and lakes. In the springtime the melting of ice in the lake cools the surrounding territory. The principle works the other way round when water freezes. In the autumn, when ponds and lakes freeze, heat is given off and the surrounding air is warmed.

G. Capillarity

Project 103 (G). Discovering how a blotter sucks up ink.

Capillarity is the name given to the process by which a blotting paper sucks up ink. Here are some experiments to illustrate capillarity.

1. Set a lump of sugar in a little red ink and notice how fast the ink rises and how high. **2.** Fill a bottle with soil or sand. Tie a piece of cloth over the mouth of the bottle. Invert the bottle in a dish of water and allow it to stand. Notice how high the water rises in the soil and how long it takes it to reach the highest point. You can try different kinds of soil, such as sand and clay. How do the results differ for each kind of soil? **3.** Get two pieces of glass of the same size — about four or five inches long. Put a rubber band around these pieces at each end, and between the edges at one end insert a piece of toothpick or match. (Fig. 129) The edges at the other end should touch. Into a plate pour a little water and red ink. Place the pieces of glass on edge in the water. Allow them to stand for a while. Notice whether the

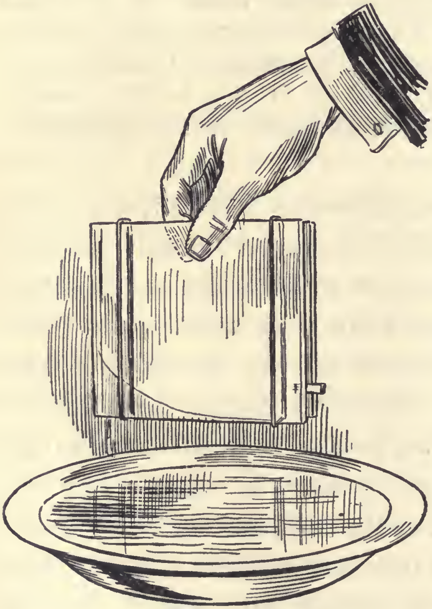


Fig. 129. Experiment to illustrate capillarity.

water rises between the plates. Make a drawing in your science notebook of the pieces of glass and the curve that the water makes.

Explanation of the experiments. There are many other common applications of this capillary action in everyday life. One is the kerosene lamp. The wick is made up of many threads wound closely together, but between which are many small passages through which the kerosene rises. One condition for the action of capillarity is the presence of very small pores through which the liquid can pass. The smaller the pores the higher the liquid rises. How did one of your experiments illustrate this fact?

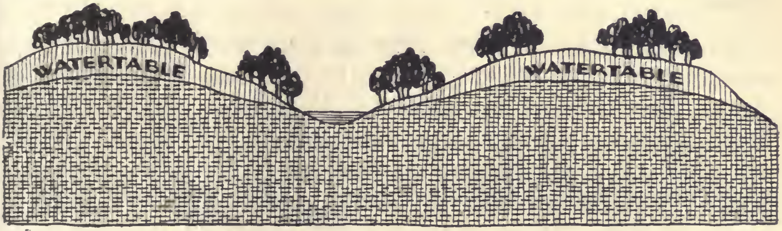


Fig. 130. The water table, from which water rises to the roots of plants through the soil by capillarity.

Another very important and common application of capillarity is seen in the soil. When rain falls, it sinks down into the soil many feet to the *water level*, that is, a place where water stands all the time (Fig. 130); and then, from this water level, the water comes back again up through the soil to the roots of growing plants, which take in the water and carry it to other parts. There may be weeks in which there is no rain, and yet plants are able to get water and live because the water is constantly being brought up by capillarity. Without this action the roots could not get water, and the plants would die. Without plants man could not get food. So you see that capillarity plays a very important part in the life of man.

H. Experiments with the Eye

Project 104 (I). **Making the illusion of looking through your hand.**

1. Take an ordinary piece of typewriting paper and, starting at a shorter edge, roll it up into a tube about three quarters of an inch in diameter. **2.** Hold the tube up to the right eye with the right hand. Hold the left hand about four inches away from the left eye with the palm toward the eye and the edge of the hand touching the tube. You will seem to see objects through a hole in the hand. The image of your left hand forms in your left eye, while an image of the hole in the tube and the objects seen through it forms in your right eye. The brain places these two images one on the other so that the hole appears to be in the same place as the hand, thus making it seem as though you were looking through a hole in your hand.

Project 105 (I). **Showing the presence of the blind spot in the eye. (Fig. 131)**

1. Close the left eye and look at the cross with the right eye. Hold the book at arm's length with the spot opposite the right eye. You will be able to see both the cross and the circle. Now slowly bring the book nearer the eye, keeping the right eye fixed intently on the cross. At a distance of about eight inches the spot disappears. As you bring the book still nearer, the spot reappears. **2.** The eye is connected with the brain by means of the optic nerve, and the spot where this nerve enters the eye is a blind spot; that is, if the image of an object falls there, we do not see the object.

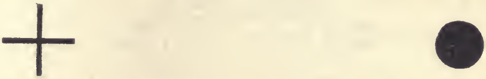


Fig. 131. Cross and spot to illustrate the blind spot in the eye.

In the above experiment, the image of the spot fell on the blind spot in the right eye. You can reverse the experiment by fixing the spot with the left eye, when the cross will disappear.

Project 106 (I). Showing the value of having two eyes.

1. Close one eye. Take a pencil in each hand and hold them vertically nearly at arm's length. Try to bring the points of the pencils together. Try again with both eyes open. What difference do you notice?

I. MOVING PICTURES

The moving picture is such a common means of entertainment that there are probably many questions which you have asked yourself about how the pictures are made and thrown on the screen. The answers to some of these questions are easy to understand, and this information will help you to get more enjoyment out of attending the movies.

What really takes place on the screen? As you watch the screen, you seem to see a continuous set of pictures of people and animals acting just as they do in real life. As a matter of fact, you do not see what really happens at all.

About sixteen separate and distinct images appear on the screen in a second; and each image is followed by a short period of time during which nothing appears on the screen, so that for about half the time the screen is darkened. You are wondering how this statement can be true when it is so contrary to what you actually see.

You will need first to examine your own eye, which sees the picture, and understand something of how it works. The eye is really very similar to a camera. In a similar way we have in the front of the eyeball a *lens*, and at the back of the eye the *retina*, which corresponds to the film in the camera. Light passes through this lens and forms images of objects on the retina. Now comes the important part of the explanation: *The image stays on the retina for a short time after the object has been removed from before the eye.* In other words, we think the object is there when it really isn't. Scientists have found that this image stays on the retina for about $\frac{1}{28}$ of a second after the object is removed.

The pictures are shown so fast that the second picture appears on the screen before the image of the first picture leaves our eye. Hence the pictures seem to be continuous. Or to explain the facts in terms of arithmetic: The image stays on the retina of the eye $\frac{1}{28}$ of a second, while the period during which the screen is dark is about $\frac{1}{32}$ of a second. Since $\frac{1}{28}$ of a second is a longer period of time than $\frac{1}{32}$ of a second, the time that the image remains on the retina bridges the gap of darkness that separates the pictures.

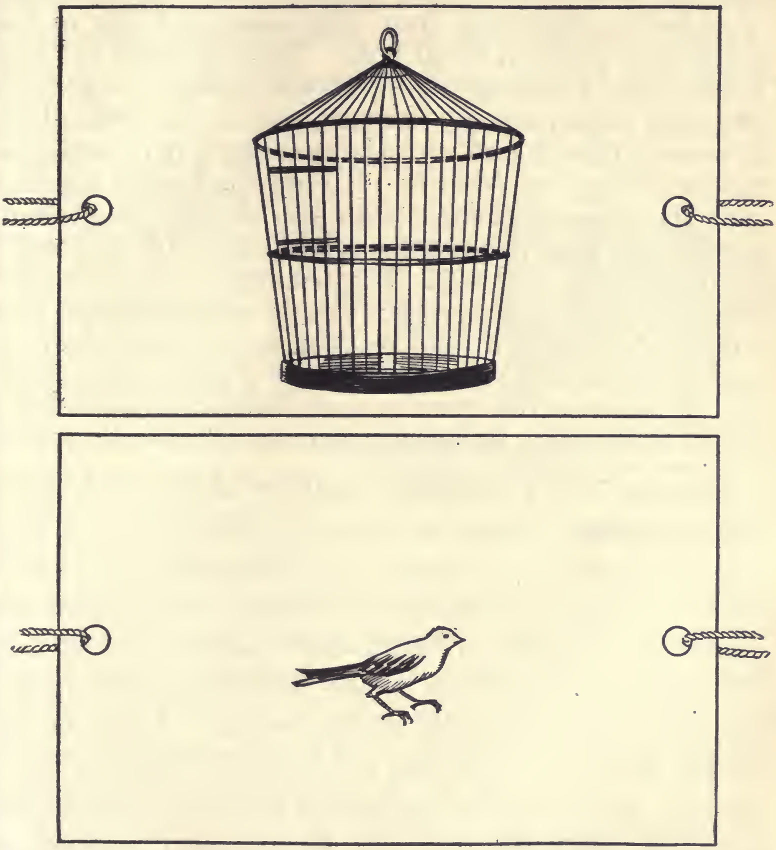


Fig. 132. Putting the bird in the cage. An experiment to illustrate the moving pictures.

Project 107 (G). Illustrating the principle of moving pictures.

1. Cut out a piece of cardboard about four or five inches square. **2.** On one side paste a colored picture of a bird. On the other side draw lines to represent the wires of a bird's cage. (Fig. 132) The pictures should be so placed that the top edge of the cardboard for the bird will be the bottom edge for the cage. **3.** About a half inch from the opposite edges of the cardboard punch a small hole. Through each of these holes pass a string about fifteen inches long. Tie the ends together so as to make a loop. **4.** Put a loop over each thumb and turn the cardboard over and over till the strings are twisted. To put the bird in his cage pull the thumbs apart. Can you explain what happens? **5.** You may make other pieces of cardboard with different pictures. For example, on each side you may paste a picture of a boy in such positions that when the cardboard revolves, the boys seem to be boxing. Or you may paste a picture of a horse on one side and of a boy on the other in such positions that the boy seems to be riding the horse when the cardboard rotates.

How is the projection machine different from a magic lantern? Now let us take a look at the machine which throws the pictures on the screen. It has a source of light and a series of lenses which throw the pictures on the screen like a magic lantern. (Fig. 133) The chief difference lies in the pictures and the means used for throwing them on the screen. First, in the magic lantern the picture is on a glass plate called a lantern slide, while in the movie machine the pictures are on a pliable film that can be rolled up; second, in the lantern the slides are all separate, while in the movie machine the pictures are all on one continuous film, like a ribbon; third, in the lantern the pictures are shown slowly, while in the movie they are shown very rapidly.

The machine that throws the pictures on the screen is called a *projector*. Along the edges of the film used in the projector are little holes, into which fit small teeth on a *sprocket* wheel, like the sprocket wheel of a bicycle, only smaller, which turns and thus rolls the film along. The film moves by jerks; and while it is being moved ahead, a shutter cuts off the light from the screen. Then the film stands still for a very short time; the shutter moves out of the way; and a picture is thrown on the screen.

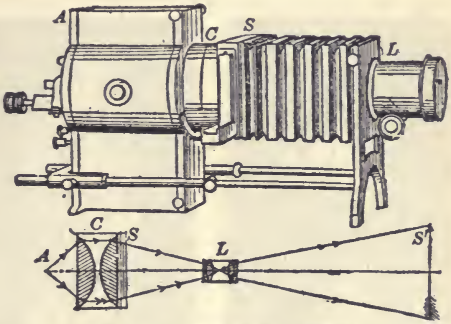


Fig. 133. The magic lantern.

For taking the pictures a special kind of camera is used which works on the same principle as the ordinary camera. The chief difference is that the moving picture camera has a device by means of which many pictures can be taken very quickly. The film is in the form of a long roll wound on a wheel fastened to the camera. As fast as the film is exposed, it is rolled up on another wheel.

This film is moved by turning a crank by hand or by a motor. The film moves by jerks, just as in the projector, and for a short period of time it is perfectly still while the picture is being taken on the film.

After the pictures are taken, the films are put through a process known as developing, by means of which the images formed on the film become visible. Then from this film, called a *negative,* a print is made on other films, the ones used in the theaters in the projection machines.

How are trick pictures made? You have seen many pictures of things that could not have happened in real life — for instance, a wheel rolling up a hill without any force behind it. In cases of this kind, a picture is first taken of the wheel rolling down hill. These pictures are taken in such a way that on the screen they can be run backwards; that is, the picture that was taken first with the camera is shown last, and so on.

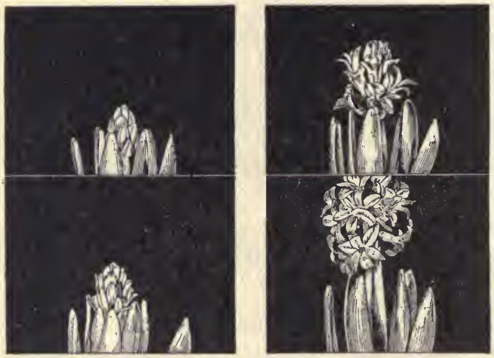


Fig. 134. Birth of a flower. Film for movies showing growth on 2nd, 4th, 6th, and 8th days.

Perhaps you have seen a picture of a rose bud opening rapidly on the screen in about one minute when you know that it takes several hours or days for it to open in nature. (Fig. 134) In this case a camera is set up before the bud and a picture taken every half hour or so for a day or two. Then they are all shown quickly on the screen.

In order to make a book or pencil appear to move across a table of its own accord, a picture of the book is taken in one position; then it is moved a short distance and another picture is taken, and so on. Then these pictures are shown rapidly on the screen and appear to be pictures of continuous motion.

Peculiar effects may be produced by tricks in exposure and printing. For example, you may have seen a picture in which the same actor is taking two parts at the same time. To produce this result one half of the film is covered and exposures made on the other half. Then the film is rewound and used again; this time the part that was exposed the first time is covered and the other half exposed. Thus the same actor by timing his movements accurately may act in both exposures successfully, and in different parts — father and son, twin brothers, grandmother and granddaughter.

In picturing accidents, dummies are often used. Just before the dangerous moment, the camera stops taking pictures and a dummy is put in place of the real actor. Then the camera starts taking pictures again. After the accident is over, the real actor may come back and take the place of the dummy.

One very interesting type of picture, that is now used commonly in such acts as horse races and football games, is one in which the objects seem to move so slowly that all the motions of the feet and hands can be plainly seen. To get this kind of a picture the camera in the first place takes the pictures very rapidly, say at the rate of eighty a second; then in the theater these are shown at the usual rate of sixteen a second. To show these eighty pictures (which were taken in one second) requires five seconds, and hence the objects seem to move only one fifth as fast on the screen as they really did move in actual life.

Another type of picture that is now very common is what is often called the "animated cartoon." In these cartoons any notion that an artist can put in drawing may be shown on the screen. In order to produce these pictures, artists make a series of many drawings. (Fig. 135) Then a photograph of each drawing is made in order on a film. In the theater these pictures are thrown very rapidly on the screen. Some of these

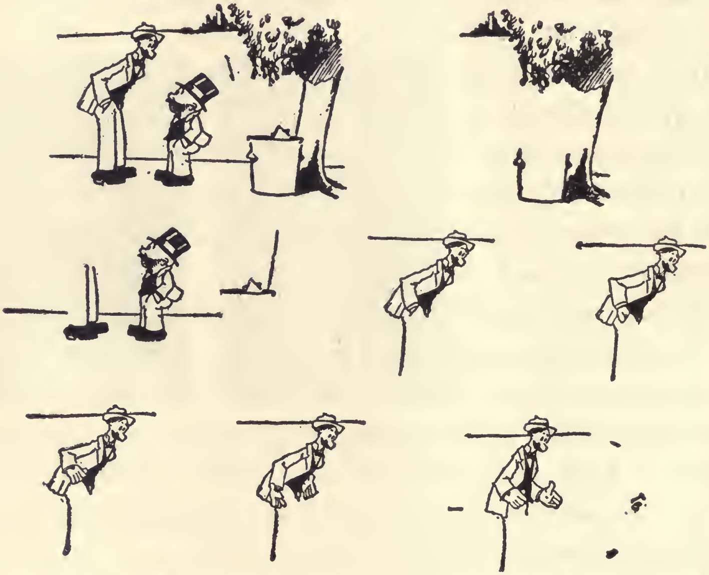


Fig. 135. Drawings for animated cartoons. These are the drawings required to show the whole process of withdrawing Mutt's hand and closing his eye.

comedies are shown in fifteen minutes, but the artists have worked for months to produce the drawings. For every minute of comedy as seen on the screen, about one thousand drawings are made.

The movies are now being used to some extent in schools. For instance, many interesting facts about peoples in other lands may be shown, such as their manner of dress and the kind of work they do. The different steps in many processes may be shown, such as the manufacturing of iron or the raising of silkworms. Pictures may be used, too, to show many things in science and nature, such as birds feeding their young, the development of the fly, or the activities of bees. Pictures of great events in history also help to make school work more enjoyable.

When you visit the movies, see whether you can tell how trick pictures were taken.

CHAPTER XIII

SKY STUDIES

A. The Sun

Our life depends upon the sun. Were the heat and light from the sun to be withdrawn from the earth, in a short time we should all perish. The sun is the center of the *solar system,* which consists of a number of planets situated at varying distances from the sun and revolving around it. (Fig. 136)

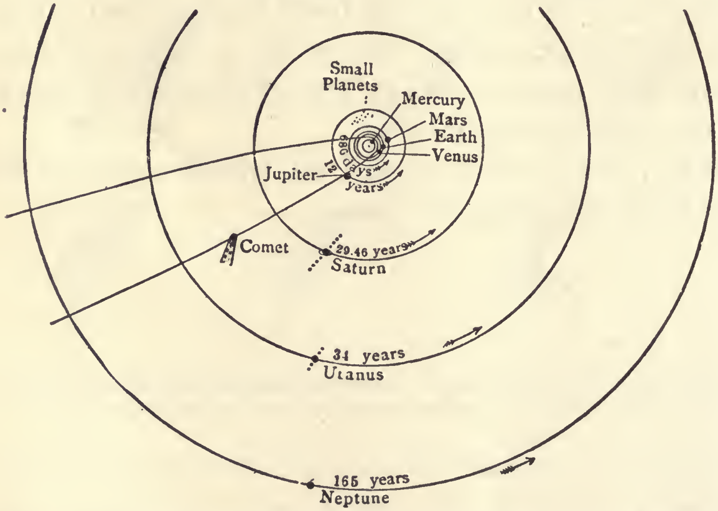

Small Planets
Mercury
Mars
Earth
Venus
686 days
12 years
Jupiter
Comet
29.46 years
Saturn
34 years
Uranus
165 years
Neptune

Fig. 136. Solar system, showing the relative distances from sun, the relative size of orbits, the number of satellites, and the period of revolution.

How does the sun differ from the earth? Let us compare the sun with the earth. The diameter of the sun is one hundred times as great as the earth, and its bulk more than a million times as great. Another great difference is in the temperature of the two bodies. The sun is so intensely hot that nothing can live there; in fact, it is hot enough to melt rocks. You can get some idea of its heat when you stop to consider that our hottest summer days are due to it; yet we are nearly a hundred millions of miles from the sun and receive only a very small part of its heat. You must not, however, think of the sun as something that is burning, for its heat is due to another cause.

Like the earth, the sun is a sphere and rotates on its axis. But it takes much longer for the sun to rotate. The earth rotates once a day and thus gives us day and night. The sun turns around once in almost a month. Thus the earth rotates twenty-eight times while the sun is rotating once. If the earth took the same time to rotate as does the sun, our nights and days would each be about two weeks long.

Project 108 (G). Making a shadow stick, to measure the change in length of the shadow cast by the sun.

1. Get a smooth piece of board from eight to ten inches square. Near one edge at the middle point bore a small hole and insert a piece of lead pencil three or four inches long. (Fig. 137) **2.** Place the shadow stick in a south window and at noon make a mark to indicate the end of the shadow. Do this about once a week for several months. How does the length of the shadow change? How many times longer is it in winter than in summer? **3.** On one day each month mark the end of the shadow for every hour for as long as you are in the schoolroom. Connect these points with a line. How does this line in the winter differ from the one in the summer?

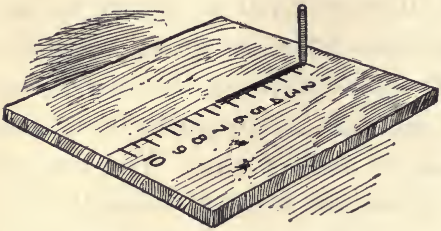


Fig. 137. A shadow stick.

B. The Moon

How does the moon differ from the sun? In one respect the sun and the moon are alike; they are both spheres. Although they look something alike, they are really very different. While the sun and the moon appear to be about the same size, the diameter of the sun is really about four hundred times as great as that of the moon. The sun is about four hundred times as far away, and that is why it looks no larger than the moon.

Another difference between the sun and the moon is that the sun is very hot and the moon very cold. It is thought that the temperature on the moon may fall at times to two hundred degrees below zero. Another important difference is that the sun shines by its own light while the moon shines by light reflected from the sun.

What does the moon look like through the telescope? Through the telescope we see that the moon is covered with many large craters — much larger than any found on the earth. (Fig. 138) These craters are thought to show that at one time the moon was so hot that the rocks came out as molten lava, just as happens now with volcanoes on the earth. There is no water on the moon. The spots which make the "man in the moon" are not seas, but simply areas of land of different appearance from the rest — plateaus. If you can get the use of a field or opera glass, look at the moon on some clear night.

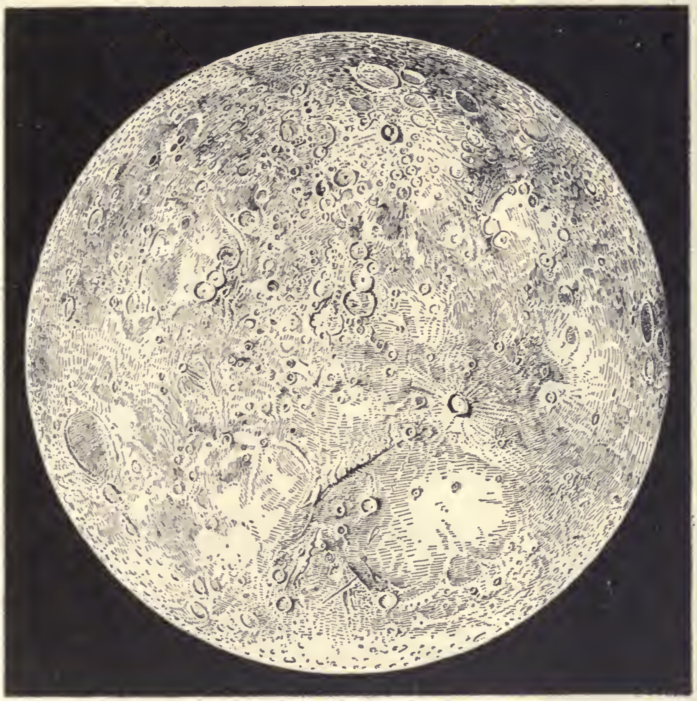


Fig. 138. Features of the moon as seen through the telescope.

What causes the phases of the moon? You have noticed, of course, that the moon is continually changing its shape; starting with a small part visible at new moon, it gradually changes to full moon, and then grows smaller. (Fig. 139) These phases depend upon the position of the moon with reference to the earth and the sun. Since the moon shines only by reflected sunlight, only that side of the moon is lighted that is toward the sun. Sometimes we can see all of this lighted portion, and at other times we can see only a part of it. The phases of the moon are the lighted parts that we can see.

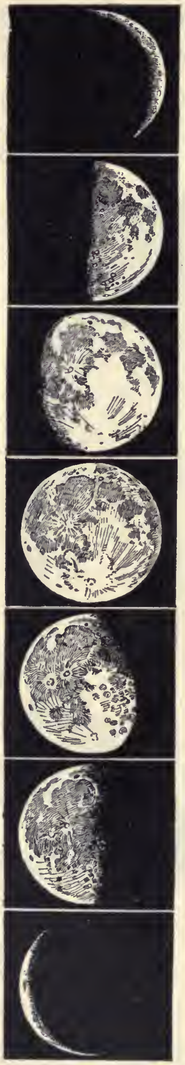


Fig. 139. Changes in phases of the moon during a month.

Project 109 (G). Illustrating the different phases of the moon.

1. Get an orange and run a knitting needle through it. Color one half of the orange white with chalk and the other half black with charcoal or ink. The white side represents the portion of the moon lighted by the sun, the black side the part in shadow. **2.** Let the window represent the sun. Let one child take the orange and walk around in a circle, turning the orange on the needle so that the white side always faces the window. This will represent only the light and the dark sides of the moon since in the moon's own movement it always keeps the same side to the earth. Light, therefore, must be thought of as sliding around the moon in its passage around the earth. **3.** Meanwhile let another pupil stand in the center of the circle and notice the portions of the white part of the orange that he can see in different positions as it is carried around the circle. **4.** Make drawings on the board to show the portions of the white half visible, and copy them in your science notebook.

What are the motions of the moon? The moon has two motions, one a rotation on its axis and another a revolution around the earth. Just as the sun is the center around which the earth revolves, so the earth is the center around which the moon revolves. Although the earth rotates on its axis 365 times while going around the sun once, the moon rotates only once on its axis while going around the earth once.

Does the moon influence the weather? The belief is still quite common that by observing the moon one can foretell the weather; that the weather is influenced by the changes of the moon's phases. Another belief is that the weather depends on the direction in which the horns of the new moon point; that if they point up, there is to be fair weather. Some sailors believe that if there is a bright star near the moon, stormy weather will follow.

All these beliefs are without foundation. Many studies of weather changes in relation to the moon have been made, and no relation between the two has been found. If the moon does have any influence on the weather, it is so small that it cannot be detected. Some farmers believe that seeds will grow better if planted during certain phases of the moon. These beliefs, too, are without foundation. It will be interesting for you and your classmates to get together all the beliefs you can find about the influence of the moon on the weather and the crops.

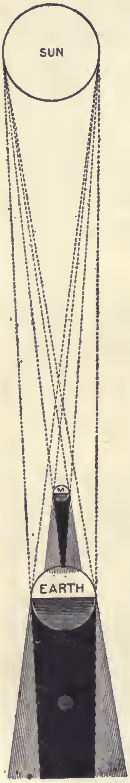


Fig. 140. How eclipses of the sun and moon take place.

The moon, however, does have one marked influence on the earth. It is the chief cause of the *tides*, the sun being another cause.

What causes eclipses of the sun and moon? Perhaps you have seen an eclipse of the moon or of the sun. There are at least two eclipses every year somewhere on the earth, and in some years there may be seven. The causes of eclipses are not difficult to understand. If you hold up a coin between the sun and your eye, you shut out the sun. In a similar way, when the moon gets between the earth and the sun there is an eclipse of the sun. An eclipse of the moon occurs when the earth gets between the sun and the moon and thus shuts off the light from the moon. Figure 140 illustrates the conditions for eclipses. When you are watching the progress of an eclipse of the sun, never let the sunlight fall directly in the eye, for fear of injury. Always have the smoked or colored glass in place before you look.

C. THE STARS

In some ways stars are the most interesting of all heavenly bodies. By the use of instruments astronomers have learned many facts about the stars. They are really suns, similar to our sun, only much farther away. If our sun were as far away as some of the stars, it would dwindle to a mere point and look like a small star.

How many stars are there? Doubtless your first thought as you look into the starry sky on a clear evening is that you see so many stars that they cannot be counted. As a matter of fact, only about 2,000 stars can be seen by the unaided eye at any one time. But when the telescope is used, the number increases to millions; and with the camera many more have been discovered which cannot be seen with the telescope. So really there are millions of stars, although we cannot see them with the naked eye. The milky way, when a telescope is used, appears as thousands of little stars, in place of what had looked like only a path of light.

How far away are the stars? An enormous distance separates us from even the nearest star. To measure distances on the earth we use the mile as the unit, but the stars are so far away that their distance from the earth cannot easily be measured by such a small unit as the mile. The unit used for measuring distances to the stars is called the light year, which is the distance that light travels in a year. Light travels at the rate of 186,000 miles a second, a distance seven times as great as the circumference of the earth. Now think of all the seconds in a day, all the days in a month, and all the months in a year, and multiply these all together to get the number of seconds in a year; then multiply this number by 186,000, and you get the number of miles light travels in a year. The nearest star is so far away that it takes its light more than four years to reach us.

In order to get some idea of how far this distance to the nearest star is, let us see how long it would take to get there traveling by the fastest device that man has ever invented. Some airplanes have traveled at the rate of three hundred miles in an hour. Let us suppose that two men start out for the nearest star in an airplane and travel day and night at the rate of three hundred miles an hour, one steering by day and the other by night. After they have traveled fifty years we will suppose that two other men take their place. At the end of each fifty years we will suppose that another change of pilots is made. It would take an army of four hundred thousand, each pair traveling fifty years at the rate of three hundred miles an hour, to reach the nearest star; and the total time required would be twelve million years.

The farthest stars are so far away that we do not know how far they are. It takes light from the North Star nearly fifty years to reach us, so that the light that you see from that star started long before you were born. It takes light from some stars hundreds of years to reach us, and from other stars thousands of years. We commonly think of the stars as fixed, but really they are moving at a rapid rate, some at the rate of 25 miles a second. They are so far away that this motion does not make any difference in their apparent position.

Those that can be seen with the eye alone have been divided into six magnitudes. The brightest are called stars of the first magnitude. There are fifteen stars of the first magnitude that can be seen in the United States. The five brightest arranged in order are: Sirius, Vega, Capella, Arcturus, Rigel.

WINTER CONSTELLATIONS

Constellation	*Bright Star* (*first magnitude*)
Orion	Rigel and Betelgeuse
Great Dog (Canis major)	Sirius (the dog star)
Little Dog (Canis minor)	Procyon
Hyades	Aldebaran
Pleiades	
Heavenly Twins (Gemini)	Pollux
Charioteer (Auriga)	Capella
Sickle (in Leo, the Lion)	Regulus

The table at the foot of the previous page gives the names of the more conspicuous winter constellations and the brightest stars.

Project 110 (I). Naming the brightest stars and constellations that may be seen in the winter time.

1. *Orion.* The most beautiful constellation in the winter heavens is Orion. You will have little trouble in finding it from a study of Figure 141. It is located well down in the southern sky. Two bright stars mark the shoulders and two more the heels of Orion. About halfway between the shoulders and the heels is the belt, composed of three bright stars in a line. Hanging down from these is another line of stars forming the sword. The bright star in the right shoulder is Betelgeuse, and the bright star in the left foot is Rigel.

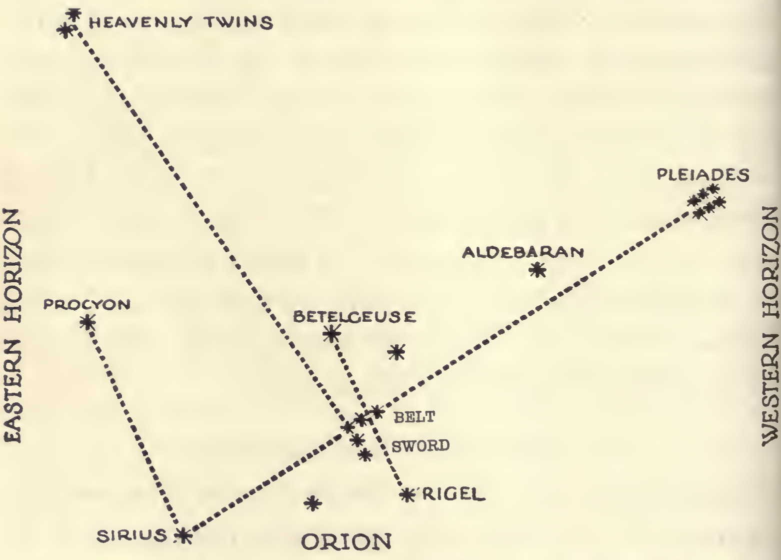

HEAVENLY TWINS
PLEIADES
EASTERN HORIZON
WESTERN HORIZON
ALDEBARAN
PROCYON
BETELGEUSE
BELT
SWORD
RIGEL
SIRIUS
ORION

Fig. 141. Chart of winter constellations. When using chart, face south.

2. *Sirius, the Great Dog Star.* Follow the three stars in the belt of Orion toward the southeast; they point toward Sirius, the brightest star in the heavens. (Fig. 141)

3. *Procyon, the Little Dog Star.* Draw a line from Rigel to Betelgeuse; starting from Sirius draw another line parallel to the first line and a little longer. It passes near Procyon. (Fig. 141)

4. *Aldebaran, in the Hyades.* Extend the line of the stars in Orion's belt in the direction opposite from Sirius and it meets a group of stars arranged like the letter V, called the Hyades. The bright star at the end of one side of the V is Aldebaran. (Fig. 141)

5. *Pleiades.* Extend the line from Orion's belt to Aldebaran nearly as far again and it passes near a group of stars called the Pleiades, containing six stars visible to the unaided eye. (Fig. 141) By means of photography more than three thousand stars have been found in this group.

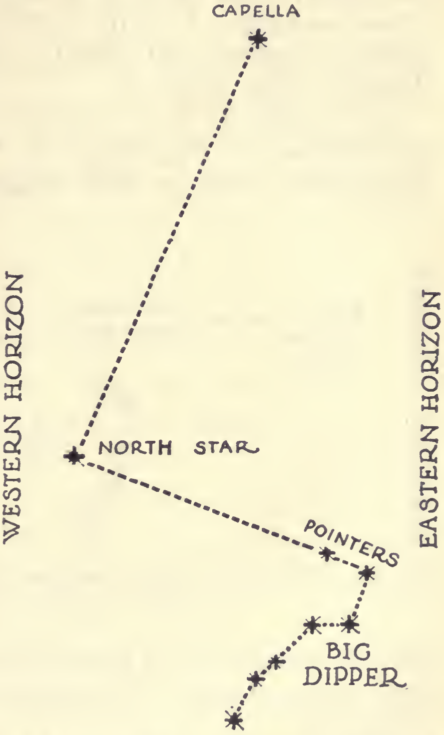


Fig. 142. Chart of Capella. Position of Big Dipper at 9 o'clock in December. When using chart, face north.

6. *The Heavenly Twins.* Draw a line from Sirius to the first star in the belt of Orion. From this star draw another line at right angles to the first (on the side away from the sword) and about two and one half times as long. It ends near two bright stars close together, Castor and Pollux, known as the Heavenly Twins. (Fig. 141)

7. *Capella in the Charioteer.* Draw a line from the pointers in the Big Dipper to the North Star. At this point draw a line at right angles to the first line (on the side away from the Little Dipper) and about one and a half times as long. It ends near a bright star, Capella. (Fig. 142)

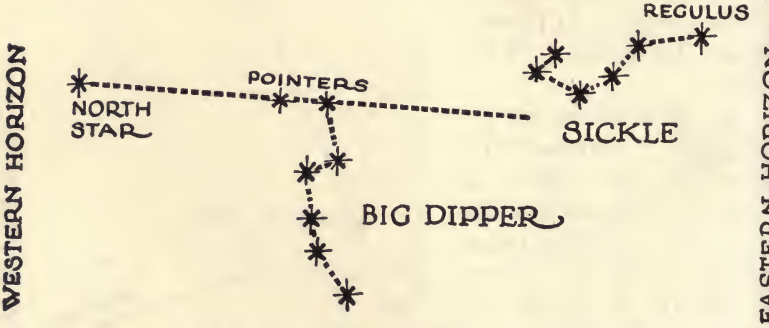


Fig. 143. Chart of the Sickle. Position of Big Dipper at 9 o'clock in January. When using chart, face north.

8. *Regulus in the Sickle.* This constellation rises considerably later than Orion and can best be seen during the late winter and early spring. To find it start with the North Star. Extend a line to the pointers in the Big Dipper; continue to extend this line about as far again. (Fig. 143) A little to one side of this line is the constellation called the Sickle. You can easily make out the handle and the curved blade. The bright star at the end of the handle is Regulus.

9. Make records in your notebook as suggested in Project 64, paragraph 7, page 119.

D. The Planets

How are planets different from stars? Planets are heavenly bodies that look much like stars and are often confounded with them. The stars twinkle, while the planets shine with a steady light. Again, a star always stays in the same position with reference to other stars, while a planet keeps changing its position. If you will notice the place of a planet with reference to some star and then watch it for a few weeks, you will see that it does not remain in the same position.

There are only eight planets, but there are so many stars that no one knows the number. All the planets are very small compared with the stars. Furthermore, there is a difference in their light-giving power. Stars shine of their own power, while planets, like the moon, shine by the light reflected from the sun.

When astronomers study planets and stars with the *telescope*, by which they enlarge and bring them nearer in vision, and learn what they really are, they find that these bodies are very different from each other — as different as our earth is from the sun. In fact, our earth is a planet and our sun is a star. There are eight planets revolving around the sun as their center. Some of these are nearer the sun than the earth is, and some are farther away. Mercury, the one nearest, is a little more than one third as far from the sun as is the earth. Neptune, the one farthest away, is thirty times as far away from the sun as is the earth. It is so far away that probably the sun, as seen from its surface, looks like a star.

These planets, like the earth, rotate on their axis and revolve around the sun. The first motion gives the day and night and the second motion the year. The length of these days and years differs according to the planet. The farther away the planet from the sun, the longer its year. The year of Mercury is 88 of our days; and the year of Neptune is 164 of our years. Why?

The planets differ in size. (Fig. 144) The diameter of Mercury, the smallest planet, is a little less than one half that of the earth; while the diameter of Jupiter, the largest planet, is about eleven times that of the earth.

Mars is one of the most interesting of the planets, because some people think that it may be inhabited. The telescope shows certain well-defined lines on the surface of Mars, and a few astronomers believe that these indicate that some intelligent beings have been working there — making canals, perhaps. However, most astonomers think that there is not sufficient evidence to lead us to believe that Mars is inhabited.

The three brightest planets are Jupiter, Venus, and Mars. Their brilliancy varies according to their distance from us, which changes from month to month. At their brightest, they are brighter than any stars.

They are known as morning and evening stars and are seen near the horizon in the early morning before sunrise and in the early evening after sunset. Venus is never seen at any other than one of these two times or at any other place than near the horizon. Jupiter and Mars may also be seen in other parts of the sky and during other times of the night.

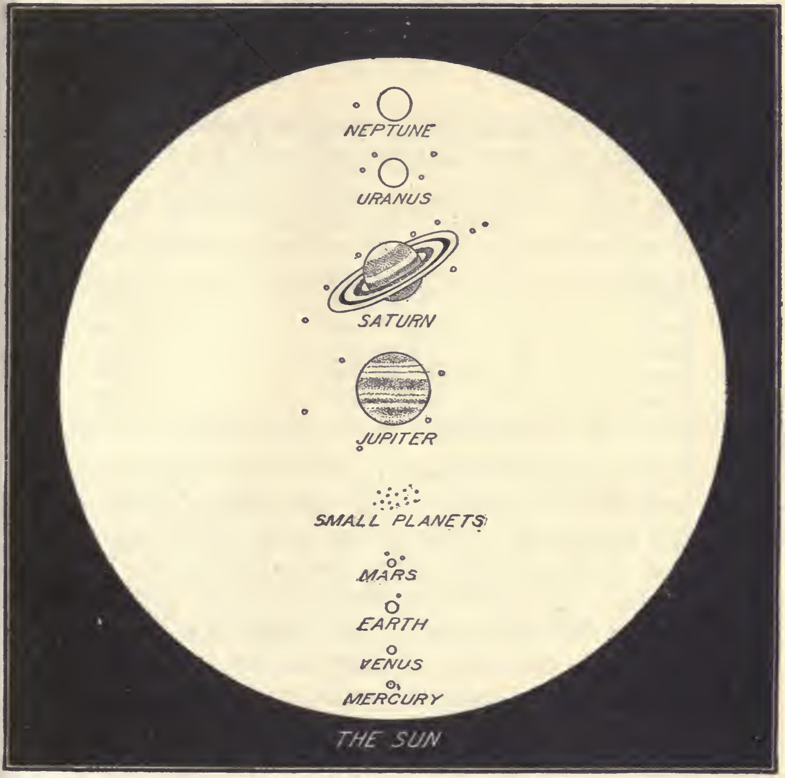

NEPTUNE
URANUS
SATURN
JUPITER
SMALL PLANETS
MARS
EARTH
VENUS
MERCURY
THE SUN

Fig. 144. Relative sizes of planets and sun.

While the earth has one moon, which revolves around it, some planets have several moons. Mars has two and Saturn eight.

Project 111 (G). **Illustrating the sizes of the planets and their distances from the sun by means of circles drawn on the blackboard.**

1. The following table gives you facts about six of the different planets which you will need for this project.

Name of planet	Distance from the sun (miles)	Diameter (miles)
Mercury	36,000,000	3,000
Venus	67,000,000	7,700
Earth	93,000,000	8,000
Mars	141,000,000	4,200
Jupiter	483,000,000	88,000
Saturn	886,000,000	75,000

2. As a convenient scale you may take one inch to represent the diameter of the earth, 8,000 miles. From the diameters given in the table work out the diameter of each planet, using the above scale. **3.** In order to show the relative distances of the planets, suppose the sun to be located at one end of the blackboard. The scale you use will depend on the length of your blackboard. Let its whole length represent 886,000,000 miles, the distance of Saturn from the sun. On this scale work out the distance of each of the other planets. **4.** Put a cross on the board in the proper location to represent each planet. At this point draw a circle of the proper size, as determined in number 2. Write the name of the planet beside the circle. **5.** Draw a circle of the proper size to represent the moon (2,000 miles is its diameter) and put it at the proper distance from the circle representing the earth.

CHAPTER XIV

PETS

It is always fun to have pets; but if we have them, they must be given good care. The purpose of this chapter is to explain just what care a few of the more common pets require, so that you can see whether you are doing things right or so that you will know what you should do.

A. The Dog

Where did the first dogs originate? If we go back far enough in the history of mankind, we learn of a time when man had no dogs. The dog has descended from some kind of wild animal. Just how man happened to get this animal and tame it we do not know exactly. We do know, however, that the dog was domesticated many hundreds of years ago, because dogs are recorded in the very early history of man. There are wild animals now, such as the wolf, the jackal, and the dingo, that are very much like dogs. (Fig. 145) It is quite possible that the first dog was domesticated by a child, who may have found the young of some wild animal and brought it home and cared for it.

Of what use are dogs? Not only have dogs served as companions, but they have been useful to man in many other ways. Different breeds have been raised for various purposes. At the present time there are two hundred breeds of dogs. The shepherd dog aids man in caring for sheep; the bulldog was formerly used in helping man to care for his cattle; to help in hunting, several kinds have been developed, such as hounds and pointers; Eskimo dogs are used to draw sleds; dogs in the Alps are trained to find lost travelers; around the home watch dogs protect children and guard the house.

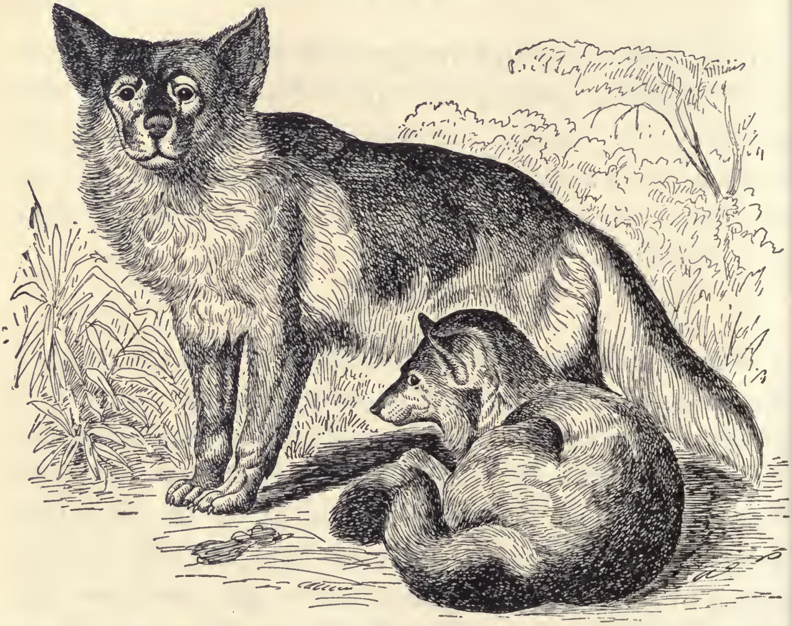
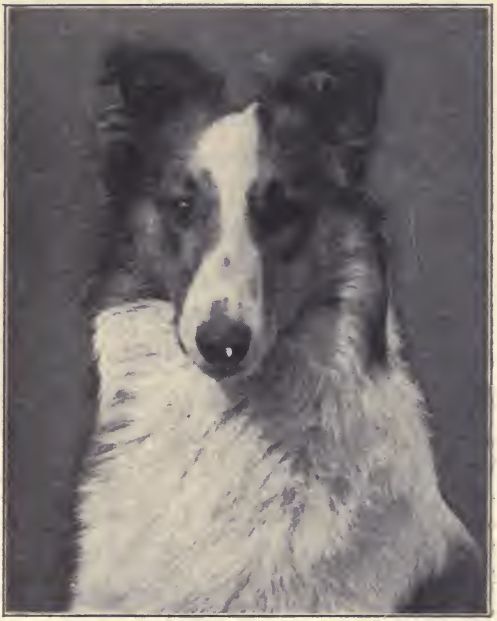


Fig. 145. The dingo, or wild dog of Australia; nearer the domestic dog than any other existing wild species.

The most interesting features of the dog. The dog has many ways of expressing its feelings and seems to understand much that we say and do. Its two chief ways of expressing itself are its bark and its motions. When pleased, it looks up joyfully; when ashamed, it drops its tail and head and slinks away; when angry, it growls and shows its teeth; if it wishes to be friendly, it wags its tail while smelling of us; if it wishes to be affectionate, it leaps upon us and licks our hands and face with its tongue; if it is afraid, it whines and lies flat on its belly; when it is waiting at attention, it stands with tail in air and head lifted toward its master.



© J. C. Allen, from Ewing Galloway, N. Y.

Fig. 146. A collie, a splendid playmate.

The dog's feet are especially adapted for running. They are provided with heavy pads to protect them and with heavy claws for digging in the ground.

The sense of smell is very keenly developed in dogs. Hunting dogs may follow the trail of a fox hours after the fox has passed. Hounds have been known to follow the trail of a fox all day long without food.

What care does a dog require? The dog should be fed twice a day. It will eat a great variety of food. Meat, preferably cooked meat, should be given it several times a week; but very little raw meat should be fed to dogs. Bones and scraps of meat from the table make excellent food. Other kinds of food that may be used are bread, cooked cereals, milk, vegetables, and dog biscuit. Sweets and much starchy food should not be given. A dish of fresh drinking water should always be in a convenient place, especially in the warm weather. Comfortable sleeping quarters should be provided. Its box should be padded with straw or excelsior, changed often enough to keep it clean. During the cold weather some sheltered spot should be provided, but it should never be as warm as an ordinary living room.

The dog should be bathed about once a week during the warm weather. A thick lather of soap suds will kill fleas. The dog should be dried as rapidly as possible and confined until dry.

Project 112 (I). Observing many interesting facts about dogs.

1. How many breeds of dogs can you discover? Notice how they differ in size, color, shape of body, head and ears, and the length of legs as compared with the body. **2.** How does a dog express fear, shame, anger, attention, delight, affection, friendliness, and excitement? Notice especially the following mediums of expression: voice, motion of tail, position of body, general activity. **3.** In connection with the dog's eating habits, notice its teeth. How many different kinds of teeth do you find? How do they differ in shape, size, and location? What use does the dog make of each kind in eating? Which does it use in gnawing a bone? **4.** How many gaits or ways of walking and running has a dog? When the snow is on the ground, notice what kind of tracks the dog makes. **5.** How do the following senses of a dog compare with yours: seeing, hearing, and smelling? Is each sense more or less keen than yours?

B. The Cat

Which makes the more interesting and useful pet to keep, the dog or the cat? In comparing the dog and the cat let us first notice their feet and teeth. Both have claws in their feet but they are used differently. Those of the dog are fixed, while those of the cat can be moved either in or out and are used to hold prey (Fig. 147). When not in use, they are drawn back within the pads. These claws are very sharp and the cat takes great pains to keep them so. Perhaps you have seen a cat sharpening its claws on a tree, post, or carpet.

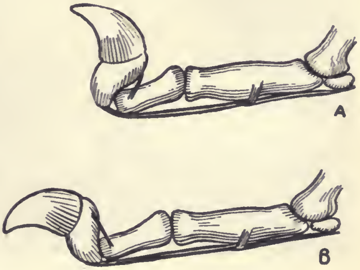


Fig. 147. Cat's claw. *A.* Claw up. *B.* Claw thrust out.

The dog and cat differ in their way of catching prey.

The dog pursues its prey in the open by chasing and overtaking it, while the cat hides itself behind something and then suddenly jumps out upon its prey. The cat's eyes are especially adapted to seeing in the dark. Its pupils become wide open, and the light is reflected from a surface at the back of the eye and is thus used twice.

The cat expresses itself very differently from the dog. One characteristic sound made by the cat is the purr, which expresses content. When a cat is frightened or hurt, or when it is fighting, it gives out shrill, disagreeable sounds which may be called snarls. Its mewing is a way in which it expresses such feelings as hunger or want. When it wishes to show affection, it purrs and rubs against its mistress, with tail erect; when it is frightened, its hair, especially on back and tail, stands on end; when angry, it moves its tail back and forth, flattens its ears against its body, and draws back the lips to expose the teeth.

Photo from Wide World Photos

Fig. 148. An aristrocrat among cats.

The cat is a very cleanly animal. It cleans its fur by means of its tongue, teeth, and paws. It may often be seen washing its face after a meal, first rubbing its face with its paw and then cleaning the paw with its tongue.

It is very interesting to watch the care that the cat gives her young kittens. The mother licks them clean with her tongue. She punishes them by cuffing their ears with her paw. She teaches them how to catch mice by bringing partly helpless mice for them to practice on.

One of the reasons that the cat is kept as a pet is on account of its value in catching mice. Some are good mousers, while some seldom catch any mice at all. Probably one half of the cats are fairly good mousers. Very few cats, however, are of any value for catching rats.

Unfortunately the cat has one very objectionable habit; it catches birds. The cat is undoubtedly the worst enemy of our song birds. The harm is done chiefly to young birds during the nesting season, but it also destroys many adult birds while they are bathing and while they are protecting their young. Cats kill birds for two reasons — they are impelled by hunger and by instinct. If the cat is well fed, the first cause will be removed; and in order to protect the birds, every person who owns a cat should see, during the nesting season (May and June), that it is shut up nights and well fed in the morning before it is let out.

What care does the cat require? Perhaps no pet is neglected so much as the cat. Often when people move from one house to another they leave the cat behind to look after itself. The cat should be fed twice a day. It is very fond of milk; this may be given with other foods such as bread or cereals. Occasionally it may be fed meat or fish. Fresh water should always be provided. A sleeping place bedded with straw or cloth should be made in a secluded spot. A cat doesn't need bathing, for she keeps herself clean.

Project 113 (I). Comparing the habits of the cat with those of the dog.

1. How does a cat express hunger, fear, friendliness, pain? In this expression what part does its tail play? What do the following sounds indicate: mewing, purring, spitting? Which has the greater variety of expressions, the dog or the cat? **2.** Compare the claws of the dog and the cat to see how they differ. Which walks more quietly? What kind of a track does each make in the snow? **3.** Watch a dog and a cat to see how they differ in the ways in which they catch their prey. **4.** How does the cat clean herself? **5.** Watch a cat with its kittens and notice what it does to them. How does it carry them? How does it punish them? How old is a kitten before its eyes are open? **6.** Do you ever see your cat with any birds? **7.** Which do you think is the more interesting pet, the dog or the cat? In what ways?

C. The Canary

Canaries came originally from the Canary Islands, just off the northwest coast of Africa, where they are still found wild. These birds have been bred for their singing and beauty until now there are some fifty breeds of canaries varying greatly in appearance. For keeping a canary a cage must be provided; this must be hung in a warm place free from draughts. The cage should be provided with perches, and sand should be sprinkled on the floor and changed frequently. (Fig. 149)

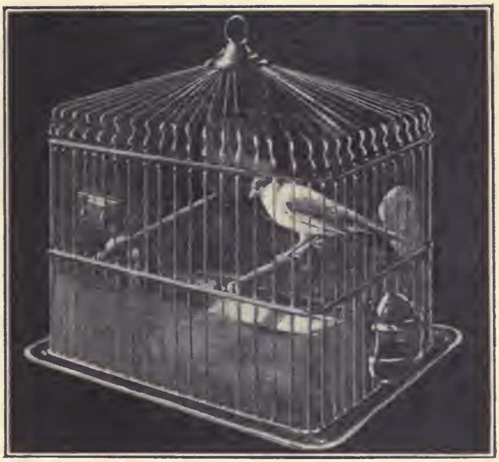


Fig. 149. A canary in cage.

What care do canaries require? The birds are best fed on canary seed especially prepared for them. Green food, such as lettuce and cabbage in summer, and apple or boiled carrot in the winter, should be provided. A piece of cuttlefish shell should always be kept attached to the cage. Water should be kept constantly in the cage and should be changed often enough to keep it fresh and cool.

The canary should be allowed frequent opportunities to bathe. The water should be warmed slightly. The bath tub may be placed on a newspaper on a table and the top of the cage placed over it.

Project 114 (I). Observing the habits of a canary.

1. If there is a pair of birds, notice how the father and mother differ in color. How do they act toward each other? Do they both sing? How many songs does the canary sing? Can you learn to imitate any of them? During what time of the day does the canary sing most? Does its singing from day to day seem to vary? Notice the motions of the bird while singing. **2.** When the bird is on the perch, notice the position of its claws. Does the canary walk or hop from one place to another? **3.** What position does the bird take while going to sleep?

Project 115 (I). Learning whether you are giving your pet proper care.

1. Watch closely for a week to see what you do for your pet. Can you find any way in which you could give it better care? **2.** *Food.* Notice how you feed your pet. What kinds of food do you give it? How much do you give and how often do you feed it? Read some book about pets and see whether you are feeding your pet in the best way. **3.** *Water.* How often do you provide water for your pet? Is the water always fresh and clean? **4.** *Shelter.* Do you provide your pet with a warm, comfortable place in which to sleep? **5.** *Bathing.* If your pet is the kind that needs bathing, how often do you give it a bath?

PART THREE

SPRING STUDIES

CHAPTER XV

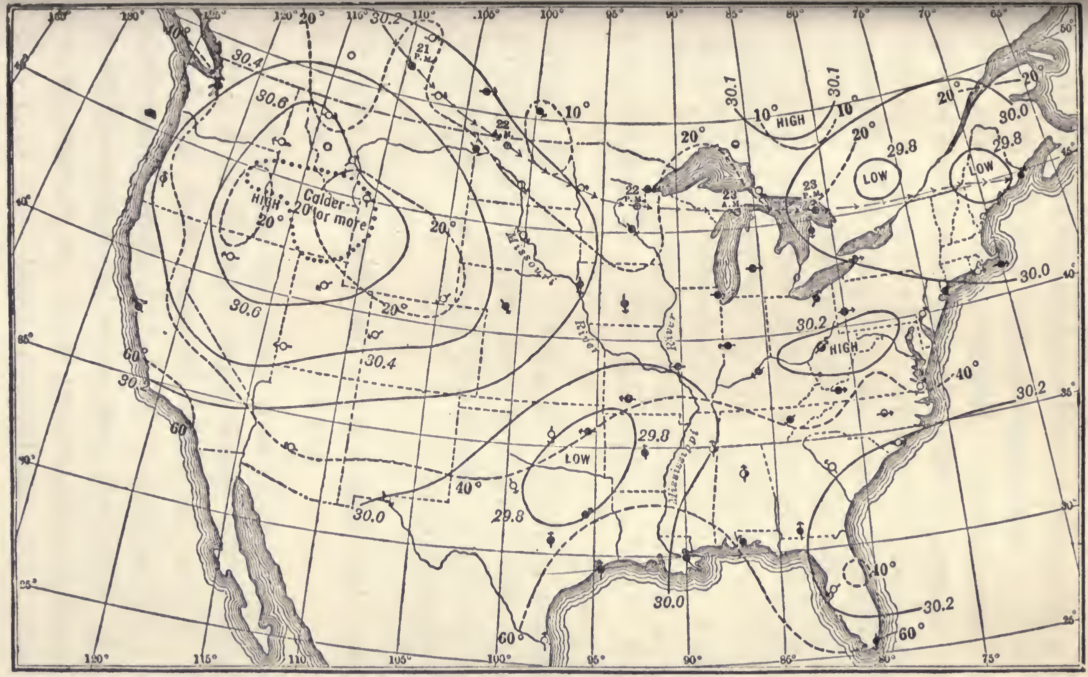
THE WEATHER

There is at Washington a department known as the *Weather Bureau,* whose business it is to give to the people of this country information concerning the coming weather. These weather forecasts are made twice daily and sent out by telegraph, telephone, and radio. At a certain hour each evening the weather forecast for the following day is broadcasted. You have seen these forecasts in the daily papers. Some people think they are not very reliable and often joke about them; but it has been discovered that they are really eighty-eight per cent accurate; that is, for every one day that they make a mistake, they are correct for seven days.

What is the value of weather forecasts? These weather reports foretell the weather conditions as to temperature, rainfall, snow, wind, and sunshine. Fruit growers, knowing of coming frost, protect their crops by lighting heaters in their orchards. Warnings of the flooded condition of rivers make it possible for people to move to places of safety and to save their property. Ship owners are warned of a coming hurricane, and protect their ships by keeping them in port. The farmer is aided in his work in many ways by knowing what the weather probabilities are for the next day or two. It is estimated that for every dollar spent in maintaining this Weather Bureau at Washington $1,680 are saved to the farmers alone, and $3,900 to everybody concerned.

How is it possible to foretell weather? Besides the central Weather Bureau at Washington, there are, scattered over the country, two hundred stations where weather records of temperature, wind, rainfall, and so on are kept twice every day. These reports are sent to Washington by telegraph. Men stationed there are provided with maps of the United States; and as soon as the reports are received, the numbers are put down on these maps. Thus there is formed a picture of the weather conditions over the whole United States at one time. The forecasts are based on these maps. (Fig. 150)

The thing that makes these maps useful is the fact that the weather conditions all tend to move eastward. If there is a heavy rainstorm at Chicago to-day, this storm will move eastward and in a few hours it will be at Cleveland. If it is cold to-night at Chicago, the cold wave will move eastward and in a short time it will be cold at Cleveland. These weather areas move eastward at the rate of several hundred miles a day, faster in winter than in summer. The men who make the forecasts know how fast these areas move at each season of the year; and in order to find out what the


HIGH
LOW
HIGH
LOW
HIGH
LOW
Colder 20° or more
30.2
30.4
30.6
30.6
30.4
30.1
30.1
29.8
29.8
30.0
30.0
30.2
30.2
29.8
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10°
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20°
20°
20°
20°
20°
40°
40°
40°
40°
60°
60°
60°
60°
90
21 P.M.
22 A.M.
22 P.M.
23 A.M.
23 P.M.
Missouri River
River
Mississippi

Fig. 150. Weather map. Observations are taken at 8 A.M. and 8 P.M., 75th meridian time. Barometer readings are reduced to sea level and standard gravity. Arrows point in the direction the wind is blowing. Solid black lines are isobars and broken lines isotherms. Paths of storms are indicated by dotted lines with arrows. Regions where colder weather occurs are shown by dotted lines.

Symbols indicate: ○ clear, ◑ partly cloudy, ● cloudy, *R* rain, *S* snow, storm warnings, *CW* cold wave warnings, ⊕→ storm track and location of storm center, date and time (A.M. or P.M.).

weather at a given place will be in a day from now, they look westward a day's journey and find the weather conditions there to-day. However, these areas are constantly changing so that the weather in two places will never be exactly the same. The forecasters know within certain limits what these changes will be and can make allowance for them in their forecasts.

For one day or a day and a half ahead, quite accurate forecasts can be made; but as the time lengthens, the forecasts become more inaccurate. Predictions in general terms are made each Saturday for the following week. No attempts are made to forecast for any longer period.

Are weather proverbs reliable? There are many weather proverbs. Some of these have no meaning or foundation whatever; others may have a certain amount of scientific foundation.

I. WEATHER PROVERBS WITHOUT SCIENTIFIC FOUNDATION

1. If the horns of the new moon tip downward, it is a wet moon; if the horns point upward, it is a dry moon. 2. When the moon changes, there will be a change in the weather. 3. A full moon brings fair weather. 4. When the new moon holds the old moon in its arms, foul weather is at hand; or in some proverbs it reads: "fair weather is at hand."

Of course the above sayings about the moon are not true. The following jingle tells the truth in this matter:

The moon and the weather
May change together;
But a change in the moon
Does not change the weather.

5. Several proverbs imply that we can foretell the weather by watching certain animals. One common saying refers to the ground hog or woodchuck. He is supposed to awaken on Candlemas Day (Feb. 2) and crawl out of his hole. If he sees his shadow, he goes back into his hole, because the winter is to continue for a long time. But if the sky is so dull that there is no shadow for him to see, then he stays out because spring will come early. 6. An early flight of wild geese south indicates an early winter. 7. If wild animals have very thick fur, the winter will be early and severe. 8. If March comes in like a lamb, it will go out like a lion. (And the other way around.) 9. If it rains on St. Swithen's Day (July 15), it will rain for forty days.

II. Weather Sayings with Some Foundation of Truth

We cannot claim that all the following proverbs are reliable means of foretelling weather, but there is enough scientific truth connected with them, so that they may have some significance.

1. A ring around the moon is a sign of a coming storm, because it shows the presence of cirrus clouds

which precede the coming of a storm — "The bigger the ring, the nearer the wet." 2. "When the stars begin to huddle, the earth will soon become a puddle." The explanation is similar to that given for No. 1. 3. The "sun drawing water" may sometimes be a sign of a coming storm, because it shows that there is quite a large amount of moisture in the air. 4. "When the peacock loudly bawls, soon we'll have both rain and squalls." An unusually clear condition of the air is shown when sounds are heard very distinctly, and this condition may be an indication of foul weather.

5. "Rain before seven, shine before eleven." This saying is true of some storms but not of all. 6. "Evening red and morning gray keep the traveler on his way. Evening gray and morning red bring down rain upon his head." 7. "Rainbow in the morning, sailors take warning; rainbow at night, sailors' delight." 8. Following is an Indian proverb: "When the locks turn damp in the scalp house, surely it will rain." The foundation for this proverb is found in the fact that hairs show the presence of moisture in the air. 9. "Mackerel sky and mare's tails make tall ships carry low sails." Clouds are one of the best indicators of weather changes.

10. "When the days grow longer, the cold grows stronger." "When the nights begin to lengthen, the heat begins to strengthen." These jingles express the truth that for most of the United States our coldest weather comes after the shortest day (Dec. 22) and our hottest weather after the longest day (June 21).

What instruments are used to measure changes in the weather? For measuring temperature, *thermometers* are used. Besides the ordinary thermometer, with which you are familiar, weather observers also have maximum and minimum thermometers to measure the highest and lowest temperatures in a given time. These are so made that the highest and lowest points to which the liquid rises and falls are shown; when one looks at a thermometer in the morning, he can tell how cold it has been during the night.

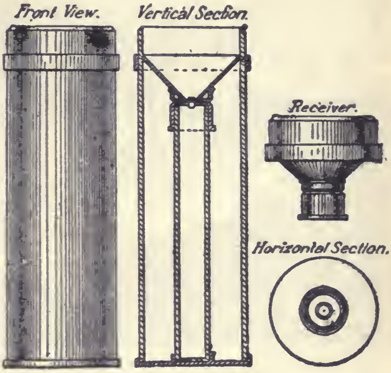
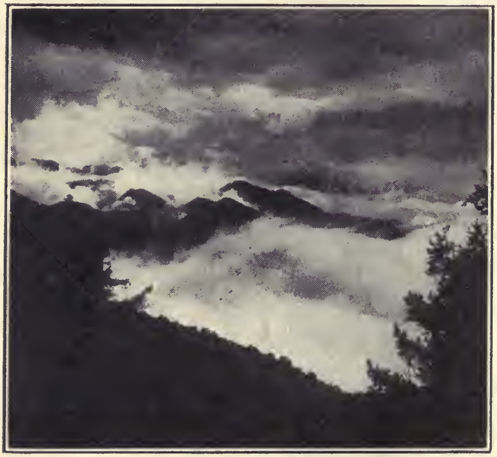


Fig. 151. Rain gauge.

For measuring rainfall, a *rain gauge* is used. This is a dish provided with a large funnel which catches the rain and brings it into a container. (Fig. 151) To measure snow, a certain amount of a known depth is secured and melted, and the water thus formed is measured. In this way each fresh fall can be measured.

The direction of the wind is measured by a weather vane. The windmill described in Project 123, page 258, is really a weather vane. In order to measure the speed or velocity of the wind, a complicated machine called the *anemometer* is used.

Temperature. As we have seen, weather is a very complicated thing and is made up of a number of factors, such as temperature, wind, rainfall or snow, and cloudiness. Perhaps the feature that we notice most of all is the temperature. This is the factor that makes the chief difference between summer and winter, and it is a factor that is constantly changing from day to day and hour to hour. Likewise it is the factor that makes the chief difference between latitudes, as the northern and southern United States. One feature that determines the attractiveness of the climate is the *range* of temperature — that is, the difference between the summer and the winter temperatures. If this range is very great, the living conditions are less pleasant.



Courtesy of U. S. Weather Bureau

Fig. 152. Stratus clouds.

Rain and snow. A second factor in weather is the amount of rain and snow that falls. In this respect we have great weather variations in the United States, ranging from those places on the American Desert with less, often much less, than ten inches of annual rainfall, to sections of the Northern Pacific Coast, where the rainfall amounts to more than eighty inches.

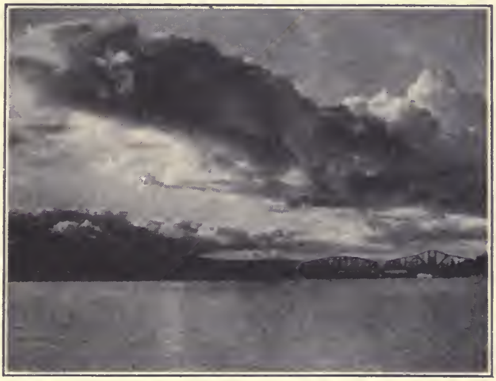
The amount of rain is an important factor in the growth of crops. As we pass westward from the Mississippi River, the amount of rainfall decreases until we come to a large area where crops cannot be grown except by irrigation.

Whether the precipitation falls as snow or rain depends on the temperature in the clouds. If the temperature is below freezing, the precipitation falls as snow; if above freezing, it falls as rain. If rain is formed and then freezes, it falls to the earth as sleet or hail.

Clouds. Clouds may be divided into four classes: *stratus*, *cumulus*, *nimbus*, and *cirrus*.

The *stratus* clouds are a kind of elevated fog and are arranged in horizontal layers. (Fig. 152) They may vary in height above the ground from a few feet to half a mile.

Cumulus clouds are thick, dense clouds with rounded tops and horizontal bases. (Fig. 153) In connection with thunderstorms, "thunder heads" are often formed. These clouds, which are about a mile high, are more common in summer than in winter.

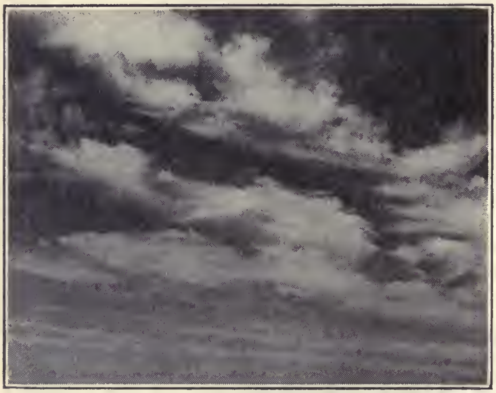


Courtesy of U. S. Weather Bureau

Fig. 153. Cumulus clouds.

Nimbus clouds are dark, formless clouds from which rain or snow descends. These are a little over a mile high.

The *cirrus* clouds are delicate, feather-like clouds of whitish color and so thin that the sun shines through them. (Fig. 154) They are five or six miles above the surface of the earth. At this height the temperature is so low that these clouds are often made of particles of ice or snow.



Courtesy of U. S. Weather Bureau

Fig. 154. Cirrus clouds.

Wind. A third factor involved in weather is wind. In the cold weather, the strong wind increases the feeling of discomfort; in the hot summer, the cool breezes make the weather more comfortable. In some prairie sections of the country the winds blow so strongly for a large part of the time that farmers plant rows of trees as windbreaks to protect them from the cold blasts of winter and the heat of summer.

How is air pressure measured? The changes in the factors that we have so far considered — temperature, wind, and snow or rain — can be easily detected by our senses. However, there are other very important changes which we cannot detect without an instrument — the changes in air pressure. Although the weight of a small amount of air is very slight, the weight of all the air above us is very great and is constantly changing. This change is measured by an instrument called the *barometer*.

The barometer (Fig. 155) is a tube about three feet long closed at one end and filled with mercury. The tube is inverted and the open end submerged under the mercury in a cup. At the upper closed end is a *vacuum* for about six inches of the tube. As the air pressure becomes greater, the mercury is forced up higher in the tube; as it decreases, the mercury falls. Thus the air pressure is measured by the varying height of this column of mercury.

The barometer is a very important instrument to use in foretelling the weather. A rising barometer indicates fair weather, while a falling barometer indicates stormy weather. Usually a high barometer accompanies fair weather and a low barometer accompanies stormy weather; but the *changes* in the reading of the barometer, rather than the exact readings, are the important points to consider. A change in the barometer reading indicates a change in the weather.

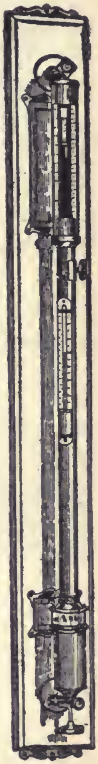


Fig. 155. A standard barometer.

Project 116 (G). Making a pictorial record of weather observations.

1. On a large piece of cardboard or heavy paper copy the calendar for a month, showing the days of the week for the entire month. **2.** Circles or squares of colored paper may be fastened on each day to represent different kinds of weather, a given color for each kind of weather — say, *yellow* for sunny, *black* for cloudy, *white* for snowy, *green* for rainy, and *red* for windy. Either gummed paper may be used or ordinary paper may be fastened on with mucilage.

Project 117 (G). Keeping weather records without using instruments.

1. Copy the following table on the blackboard or on a heavy piece of cardboard:

Date	Temperature	Sky	Wind	Precipitation		Clouds
				Kind	Amount	

2. At the same time each day for a month record the facts about the weather. Under *temperature* record whether it is *hot*, *warm*, or *cool;* under *sky*, whether *clear* or *cloudy;* under *wind*, the force, whether *calm*, *light*, or *heavy;* under *kind* of precipitation whether *rain* or *snow;* under *amount*, whether *light* or *heavy;* under *clouds*, the kind, whether *stratus*, *cumulus*, *nimbus*, or *cirrus*. **3.** Copy the table in your science notebook.

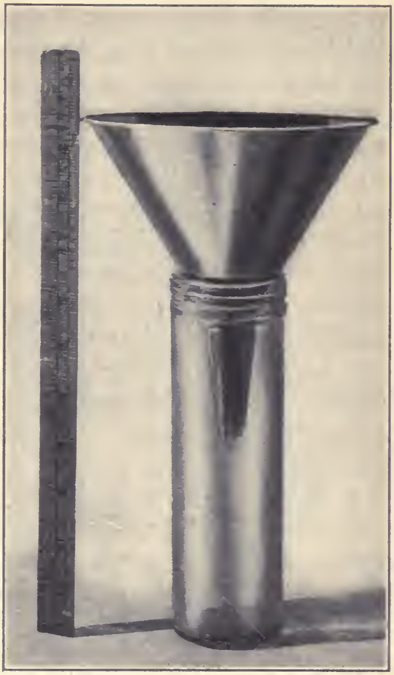


Fig. 156. Home-made rain gauge.

Project 118 (G). Keeping weather records with instruments.

1. For these records you will need the following instruments: a thermometer, a rain gauge, and a weather vane. Perhaps, also, you can find (at the high school) a barometer, whose readings you may be allowed to take daily. **2.** One of you can make a rain gauge that will serve your purpose. Get a small glass bottle with straight sides, such as preserves come in, a tin funnel about five inches across, and a ruler. (Fig. 156) **3.** Take turns in recording the readings on the blackboard or on a piece of heavy paper, according to the following table:

Date	Hour	Temperature (outdoors)	Clouds	Wind		Amount of rainfall
				Direction	Force	

4. Make your records at the same time each day, preferably in the morning, and keep them for a month.

5. Under *clouds,* record the cloudiness in tenths; ten tenths (1.0) if all cloudy; no tenths (.0) if all clear; five tenths (.5) if half cloudy; and so on. **6.** To determine the *direction* of the wind, use any neighboring weather vane. If there is none near you, you can easily make one and put it up in some exposed position. (Project 123) **7.** Under *force,* record one of the following: *calm* (no wind); *light* (just moving the leaves of the trees); *moderate* (moving the branches); *brisk* (blowing up dust); *high* (swaying whole trees). **8.** The rain gauge should be put in some protected place not too near a building, as on a flat roof. To find the amount of rainfall measure the height in inches of the water in the bottle. Divide this distance by a figure which the teacher will give you.[1]

9. Copy into your science notebook the figures from the board. **10.** On the days that it rains, notice the direction of the wind. Is there any uniformity about the direction? What is true of the direction of the wind on fair days?

Project 119 (G). Making a water barometer. (Fig. 157)

1. Get a pint canning jar and a soda water bottle. Fill the jar about a third full of water. Put a little water in the soda bottle. Quickly invert the bottle in the jar. The water in the neck of the bottle should be about on a level with the water in the jar. If it is not the first time you invert the bottle, try again, putting different amounts of water in the bottle, till you get the water in the bottle as you want it. **2**. The water in the neck of the bottle will rise or fall according to the pressure of the air. A change in the level of the water indicates a change in weather. Generally a rise indicates fair weather, while a fall indicates stormy weather.

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[1] This figure will need to be supplied by the teacher as the method of securing it is too difficult for children to work out. However, they may be told the meaning of the ratio or divisor. Find the diameter in inches or fractions thereof of the inside of the bottom of the bottle (assuming it to be circular); then compute the area, using this formula: area equals $\frac{22}{7}\times r^2$, in which r equals half the diameter. In the same way find the area of the large end of the funnel. Divide this latter area by the area of the bottom of the bottle. The height of the water in the bottle is then to be divided by this ratio between the two areas just found. The quotient is the amount of rainfall in inches.

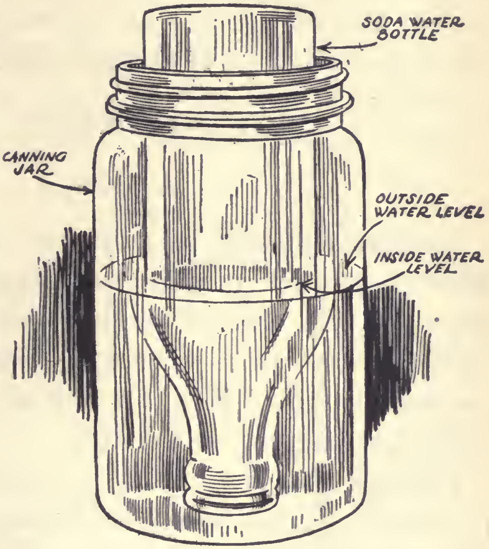


Fig. 157. Water barometer.

Project 120 (G). **Finding the dew point.**

1. Procure a tin cup with a bright surface, a thermometer, salt, and some crushed ice. **2.** Fill the cup about half full of ice and salt, in the proportion of about three parts of ice to one of salt. Put a thermometer into the ice. Occasionally stir the mixture. **3.** When moisture forms on the outside of the cup, read the thermometer. This is the dew point. If all the air in the room were to be lowered to this temperature, what would happen?

CHAPTER XVI

TOYS FOR WINDY DAYS

A. Kites

We think of a kite as a toy for windy days, but kites have been used for practical purposes as well as for sport. A kite carried the first wire across the Niagara River to start the suspension bridge there. The government has used kites for making records of weather conditions high up in the air.

Perhaps you have heard of Franklin's kite. When he wished to experiment with lightning, he sent up a kite during a thunderstorm. The string of the kite became wet, and he found that he could take electricity from the string and strike sparks just as with electric machines. This experiment became famous, because it showed that the lightning in the clouds is produced by the same kind of electricity as that generated by friction on the earth.

There are many kinds of kites. There is the ordinary tailed kite, which must have some weight in the form of a tail to make it balance. There is the tailless kite, sometimes called the Malay kite, which is so made that it will balance without a tail. And, finally, there is the box kite, made in the shape of a box with sticks along the edges.

A good kite should combine lightness with strength. In order to obtain lightness, as light a covering and as few sticks as possible are used. Strength is secured by the stiffness of the frame, by the way its parts are fastened together, and by the boundary line. Spruce is one of the best woods for the frame. Linen fishline is good for the bridle (Fig. 158), the lashings, and the boundary line.

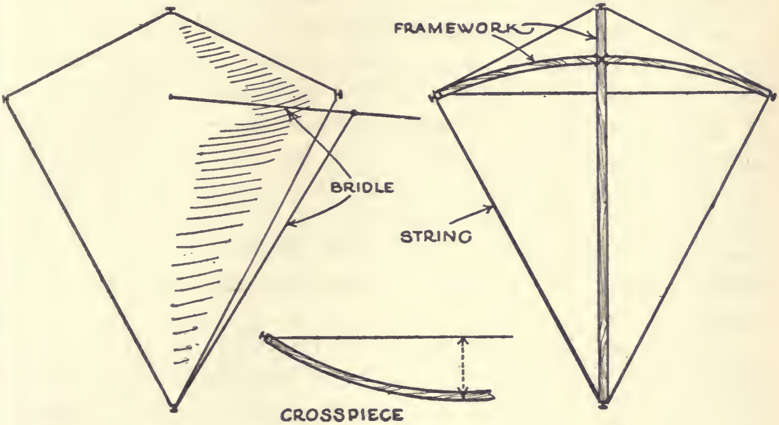


Fig. 158. Tailless kite.

Project 121 (I). **Making a tailless kite.**

1. Procure two strips of wood each three feet long, about one half inch wide, and a quarter of an inch thick. Drive a large tack or small nail into the two ends of each stick. Near each end of one piece make a notch so that a string can be tied. This stick is called the crosspiece. **2.** Fasten the crosspiece at right angles in the middle, five and one half inches from one end of the other piece. (Fig. 158) Drive two small nails through the pieces to hold them together, and wind linen thread around the connections so as to make them stronger.

3. Get a strong string about three and one half feet long and tie it to one end of the crosspiece at the notch. Then tie the string to the other end of the crosspiece, bending the strip of wood into the form of a bow so that the distance from the string to the bow at the center is four and one half inches, or about twelve per cent of the length of the crosspiece. (Fig. 158) **4.** Either longer or shorter sticks may be used if the same proportions are kept; that is, the crosspiece must be fastened at a distance from the end of about fifteen per cent of its length and should be bent so that the distance between the crosspiece and the string at the widest point (the center) is about twelve per cent of its length.

5. Connect the four ends of the sticks with a string, which should be fastened around the nails in the ends. To cover the frame, secure a piece of light-weight wrapping paper. Lay the kite frame on this, and cut off the paper about two inches from the string. Place the convex or bulging side of the bow next to the paper, fold the two-inch edge of the paper over the string and fasten it down with paste, allowing the paper to bag a little so as to form pockets for the wind.

6. To make the bridle (Fig. 158) fasten one piece of string to the lower end of the upright piece and another piece of string at the place where the upright piece and crosspiece meet. Make a little hole in the paper over this intersection in order that the string may be passed through. The kite is to fly with the convex or bulging side facing the wind. Tie these two strings together at such a place that when held over to one side the knot will be just over the end of the bow; that is, the string fastened to the intersection should be one half as wide as the kite, and the piece fastened at the lower end should equal the distance from this end to the end of the crosspiece. (Fig. 158) Tie the flying line securely at the point where this knot that fastens the two strings of the bridle is made.

B. Windmills

Windmills are often used to pump water and are a cheap source of power because the wind is free. The one objection to the windmill is that it can only be used when the wind blows, and there may be a calm lasting for several days when no water can be pumped. Men who use the windmill for pumping water usually have a tank big enough to hold a supply for several days.

In order to observe closely how the wind acts on the windmill to make it revolve, you will enjoy making some toy windmills. In the following projects you will be told how to make one of paper and one of wood.

Project 122 (I). Making a paper windmill.

1. Procure a piece of ordinary wrapping paper about five or six inches square, a pin, and a pencil with a rubber on the end. **2.** Lay the paper down on the desk and draw straight lines between the diagonally opposite corners. With a pair of scissors cut along each of these four lines to within one-half inch of where the lines cross. **3.** Turn over every other one of these points toward the center and overlap the four points.

Pass a pin through these where the lines cross, and then into the rubber of a pencil. (Fig. 201, page 339) **4.** Try blowing on this windmill. Hold it over a radiator or hot air register. Hold it outdoors in a wind. Run with it held before you.

Project 123 (I). Making a wooden windmill. (Fig. 159)

1. Procure two pieces of wood about six inches long and from three quarters of an inch to one inch thick each way. Pieces may be sawed out of an ordinary board. **2.** Find the center point of each stick. On each side of this point measure a distance equal to one half the width of the stick. At each of these points draw a line across the stick. Turn the sticks over and do the same on the other side. **3.** Beginning at the end of these lines, whittle along the edge down to the end of the stick on both sides until it is a thin blade,

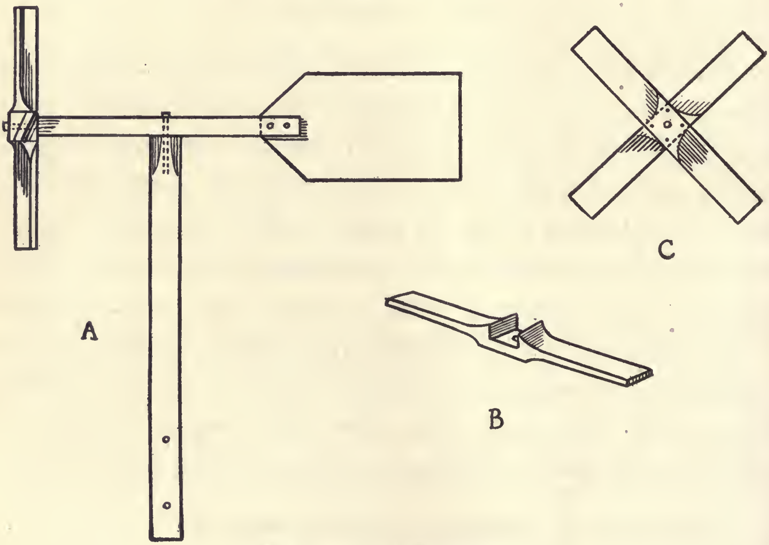


Fig. 159. Toy windmill.

like that shown in Figure 159, B. Now whittle off the other end of the stick in the same way, only start from the other edges. Make the second stick in the same way.

4. Starting with the two parallel lines first drawn near the center of the stick, saw down on one side halfway through. Cut out this piece with a chisel. Saw the other stick in the same way. Now fit these two sticks together and fasten them with small nails in the corners. (Fig. 159, C) By means of a gimlet, bore a small hole for a nail through the middle of the sticks, but large enough for the mill to move around the nail. **5.** Secure a stick about six inches long and one-half inch square. On one end nail a piece of very thin board two or three inches wide and four or five inches long. Whittle off the corners from the other end, making it round. (Fig. 159, A) **6.** Pass a nail through the hole in the fans and drive it into the end of the stick. **7.** Place the stick on your finger and find the point at which it now balances. At this point bore a small nail hole with a gimlet, holding the stick so that the thin board stands up and down. (Fig. 159, A)

8. The last step is to provide a support for this windmill. Secure a stick six or eight inches long and about three quarters of an inch square. Whittle off the corners at one end until it is round. Pass a nail through the hole in the cross-stick and drive it into this end. Now nail up the other end in some situation exposed to the wind.

CHAPTER XVII

GARDENING

Why should one plant a garden? There are several reasons why boys and girls like to garden. In the first place there is pleasure in gardening. One likes to watch the seedlings as they first come above the ground and to see them grow larger. One enjoys especially raising beautiful flowers. (Fig. 160) A second reason that gardening appeals to girls and boys is that it gives an opportunity to earn money. One can often

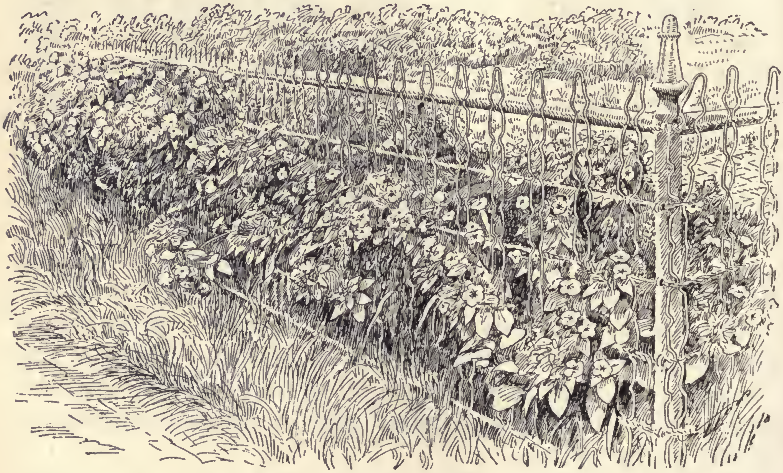


Fig. 160. A border of four-o'clocks.

sell the products of the garden, either to one's family, to neighbors, or to the store. (Fig. 161) Still another reason for having a garden is that it is excellent for the health; it gives one exercise outdoors in the pure air. (Fig. 162)

Fig. 161. Counting the profits from the garden.

A. MAKING A PLAN

Before you begin to plant your garden make a plan on paper, showing what you want to plant. Draw lines to represent the different rows. On each line write the name of the vegetable that you are going to plant and the distance that you wish to leave between the rows. This plan can be made in the winter time. It is not wise to plant in a small garden vegetables that take up a great deal of room, such as melons, pumpkins, and potatoes.

B. PREPARATIONS

In the early spring, the garden should be covered with manure and spaded. Then before planting the seeds rake over the soil carefully, making it smooth and taking out the lumps and sticks. Your garden will look much neater and be easier to take care of if you plant your seeds in straight rows. As a guide in marking out the rows, you may use either the handle of a garden rake or a string tied from one stake to another. (Fig. 163)

© *J. C. Allen, from Ewing Galloway, N. Y.*

Fig. 162. At work in the garden.

C. Planting the Seeds

When planting seeds you need to consider three things: the time, the depth, and the distance apart. According to the time at which they may be planted, vegetables are divided into two groups, hardy and tender. The seedlings of the hardy vegetables are not injured by the spring frost, while those of the tender are. The tender vegetables should be planted about one month later than the hardy. The exact time varies with the locality; the farther north you are, the later your seeds should be planted.

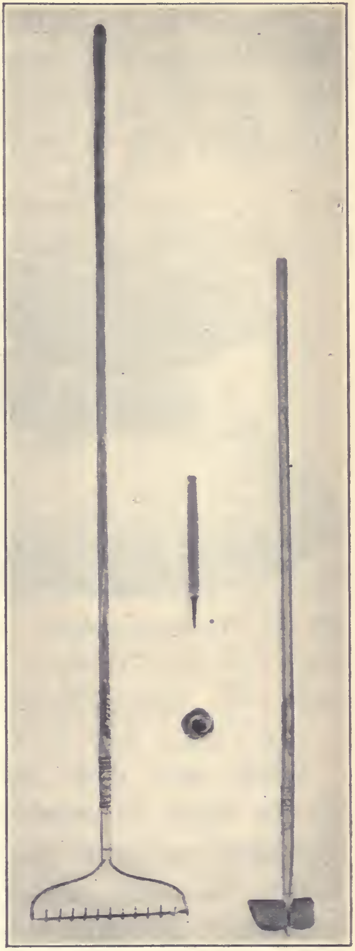


Fig. 163. Garden tools.

The depth of planting a seed depends on its size; the bigger the seed, the deeper it should be planted. A general rule is to plant the seed at a depth equal to three or four times its diameter.

The distance apart that seeds should be planted depends on the size of the plant when it is full grown. Some seeds, like those of the radish, are planted close together; while others, like those of the squash (Fig. 164), are planted far apart. Some, like peas, are planted in drills; that is, scattered all along in the row. Others, like cucumbers, are planted in hills.

Such plants as tomatoes take so long to mature that it is better to start them indoors early in the season and then transplant them when the warm weather comes, or to buy them at the florist's.

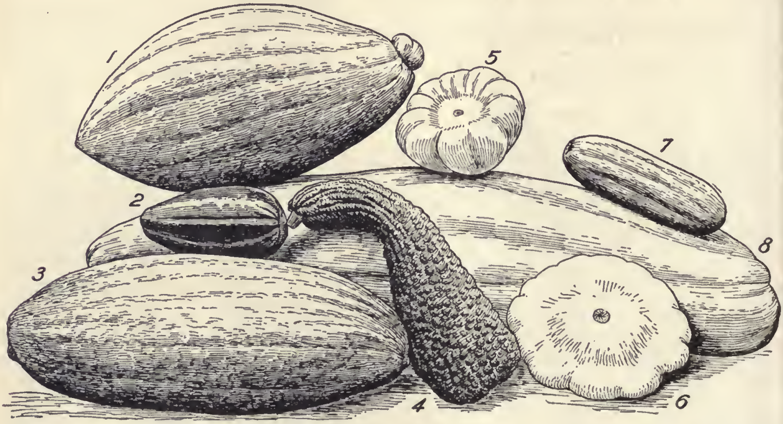


Fig. 164. Varieties of squashes. 1, 2, 3, 7, 8, winter varieties; 4, 5, 6, summer varieties.

D. Caring for the Garden

What care does the garden require? After the plants begin to come up, they should be cared for. The chief care is to hoe the garden for the purpose of killing the weeds, which, if allowed to grow, will harm the plants you want to raise. Another care that many plants require is thinning. This should be done when the plants are young. If the young plants are not thinned, they become crowded as they grow larger; and there is not room enough for them to grow to their ordinary size.

The following table gives in condensed form some of the important facts regarding the raising of a few common vegetables. The dates given for the first sowing of seeds are for the latitude of New York City.

Name	Date to sow	Depth to plant (inches)	Rows apart (feet)	Plants apart (inches)	Days required to come up	Time to mature (days)
radish .	Apr. 15	½	1	1–2 [1]	4	20–40
lettuce .	Apr. 15	¼	1	4–6 [1]	4–8	60–90
peas . .	Apr. 15	3	2½	1	7–10	40–80
beets .	Apr. 15	1	1	3–4 [1]	6	60–80
corn . .	May 1	2–3	2½–3	30–36	8	60–100
beans . (bush)	May 1	2	1½	2–3	8	40–65
squash . (summer)	May 15	1	4	48	11	60–80

[1] Distance to which plants should be thinned. Seeds should be planted much closer.

The table on the following page gives a few facts about ten common annual flowering plants. The dates for planting are for the latitude of New York City.

Project 124 (G). **Making garden charts.**

1. Get four large pieces of heavy paper. Across the top of one write in large letters, *Vegetables whose roots we eat;* across the top of another, *Vegetables whose fruit we eat.* The other two should bear the titles: *Hardy annual flowers* and *Tender annual flowers.* **2.** If you will look through magazines and papers, you will find many advertisements of seeds. Bring some of them to school; also bring a postal card. Under the direction of the teacher, write a postal asking for a catalogue. **3.** When the catalogues come, you can cut from them, and from any other sources, pictures to illustrate the four headings given above. Arrange them in order and paste them on the chart.

Name	Height (feet)	Color	Time of bloom	Time to plant	Days required to come up	Distance to thin out (inches)
sweet pea . .	4–6	purple scarlet white pink	June–Oct.	March	7–20	4
nasturtium .	1–6	orange red yellow	July–Oct.	April 15	10	6
candytuft . .	½	red white	June–Sept.	April 15	4–9	6
zinnia . . .	1½–2	red scarlet yellow	July–Oct.	April 15	5	6
cornflower . .	1–2	blue	July–Sept.	May 1	5	6
morning-glory	15–20	blue red white	Aug.–Oct.	May 1	5–6	6
sunflower . .	5–7	yellow	Aug.–Oct.	May 1	5	24
aster . . .	1	blue red white	Sept.–Oct.	May 10	5–10	6
marigold . .	1–2	yellow	Aug.–Oct.	May 15	5	8
portulaca . .	½	red white	July–Sept.	June 1	5–15	4

Project 125 (G). Observing what happens to the parts of a seed when it first begins to grow.

1. A seed is really a little plant containing leaves and stem but no roots. Get some beans and peas and soak them over night. **2.** Open a soaked bean and a soaked pea. You will find two kinds of leaves — the large fleshy leaves, called seed leaves, which make up most of the seeds, and the small leaves, called the *plumules*. Find also the small stem between the seed leaves. Make a drawing of each opened seed.

3. Roll up a piece of blotting paper and put it in a tumbler. Place two or three soaked beans or peas between the paper and the glass. Fill the space in the middle of the blotting paper with sand or soil. (Fig. 165) **4.** Put the tumbler in a warm place and keep the soil watered. **5.** Watch the seeds grow and see what happens to each part of the seed. Make a series of drawings every few days to show the changes which take place. **6.** What is the difference between the pea and the bean in the development of the seed leaves?

7. Or, put two thicknesses of moist blotting paper in a plate. On this place some soaked pea and bean seeds. Put another piece of cloth or blotting paper over the seeds. Over all invert another plate. The paper or cloth should be kept moist. The plate and cloth can be easily lifted in order to watch the seeds. **8.** Plant some soaked seeds of corn, pea, and bean in some soil kept in a box. Keep the soil watered. Notice the different ways in which the seedlings break through the soil.

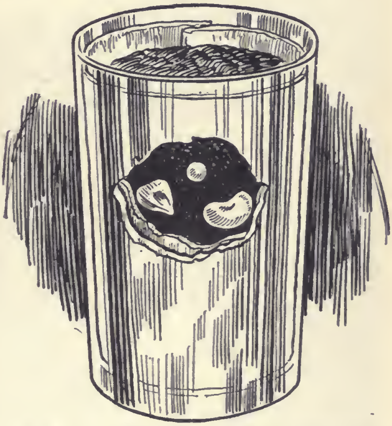


Fig. 165. Tumbler for germinating seeds.

Project 126 (G). Securing penny packets of seeds to plant in your gardens.

1. In order to encourage children to plant seeds, a company has been formed that sells seeds for a penny a packet. It is known as the Children's Flower Mission and is located in Cleveland, Ohio. One of you can write

Fig. 166. A gardener and his tools.

a letter to this address telling how many children there are in your room and asking for a circular for each child.

2. When the blanks come, you may take them home and after talking the matter over with your parents, check off the kinds of seeds you want to order. Take your order and money to the teacher. She will send all the orders together to the company. Soon your seeds will be sent to you in separate packages.

Project 127 (G). Watching a race among seedlings.

1. Procure a small box and fill it about three fourths full of ordinary garden soil. Secure three seeds of each of the following: pea, bean, corn, and radish. Soak them over night in water. Plant them at the proper depth in the box; the bigger the seed, the deeper it should be planted. Plant each seed at a depth equal to three times its diameter. Keep the soil well watered.

2. Next arrange for points by which you can score the different seedlings when they come up. The following is suggested:

Winning Points	*Score*
First seedling to appear above ground . .	35 points
First seedling to straighten up its stem . .	15 ”
First seedling to grow new leaves (after seed leaves)	25 ”
First seedling to reach height of two inches	25 ”

At the end of the race count five points for each leaf present on each seedling.

3. Write the names of the seeds on the board or on a piece of paper. Watch the growth of the seedlings and give each one the proper number of points according to the above table. See which seedling has the highest score at the end of the race.

Project 128 (I). **Making a plan of the vegetable garden.**

1. Measure the length and breadth of your garden. On a page of your science notebook draw lines to represent the boundaries of your garden. **2.** After you decide what you want to plant, draw lines on this paper to represent rows, a separate line for each row. On each line write the name of the seed and after it the distance between the rows, expressed in feet. **3.** Plan your garden in such a way that the distances between the rows when added together will equal the total length of your garden.

Project 129 (I). **Making an early garden.**

1. In the early spring plant some seeds of a few hardy annual flowers such as sweet alyssum, bachelor's button, nasturtium, California poppy, petunia, sunflower, sweet peas, and zinnia. **2.** Plant seeds of the vegetables whose roots are eaten, such as the beet, carrot, oyster plant, radish, parsnip, and turnip. Try at least one new vegetable that you have never raised before. Since these are all hardy plants, the seeds may be planted in the spring as soon as the garden is ready.

Project 130 (G). **Learning at what depth seeds should be planted.**

1. Procure a small box and fill it with soil. Seeds of lettuce, radishes, and peas may be planted. The first are small, the second medium sized, and the third large. **2.** Mark off the soil into four squares. In one square plant five seeds of each of the three kinds, a quarter of an inch deep; in the second square plant five, one inch deep; in the third plant five, two inches deep; and in the fourth plant five, four inches deep. **3.** Put the box in a warm place and keep the soil watered.

4. Watch for the seedlings to come up and keep a record in your science notebook as follows:

NUMBER OF DAYS TO COME UP

Name of seed	Planted ½ inch	Planted 1 inch	Planted 2 inches	Planted 4 inches
lettuce . .				
radishes . .				
peas . . .				

5. What have you learned from this experiment?

Project 131 (G). Discovering how the little squash seedling gets out of its tough seed coat. (Fig. 167)

1. Procure two plates, some pieces of blotting paper, and some squash seeds. 2. Put two pieces of moist blotting paper in one plate. On these pieces of paper put five or six squash seeds that have been soaked over night. Over this put two thicknesses of moist blotting paper. Over all invert the other plate, which will keep the blotting paper from drying up quickly. 3. Allow the plates to stand in a warm place, and add enough water from time to time to keep the paper moist. 4. When the seeds begin to germinate, watch to see how the seedlings get out of the coat. Make a series of drawings in your science notebook.

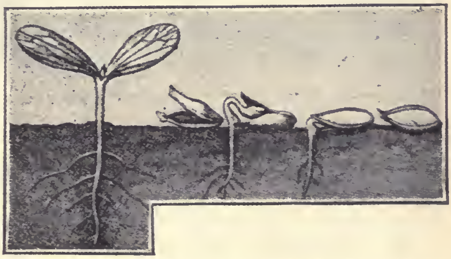


Fig. 167. Germinating squash seeds, showing how seed leaves get out of seed coat.

Project 132 (G). Making a pocket garden in which the growth of seedlings may be watched. (Fig. 168)

1. You can work in groups to carry out this plan, each group making a garden. Procure two pieces of glass of the same size, about four to six inches each way. **2.** Lay one piece of glass on the desk and on it put a piece of blotting paper of the same size. Cut strips of blotting paper about a quarter of an inch wide. Place these, two-deep, around the edge of the first piece of blotting paper. **3.** Within the inclosure thus made, place four or five seeds of radishes. Place the other piece of glass on top and put two rubber bands around the whole. **4.** Stand the glass on edge in a plate of water until all the paper becomes wet. Then set it aside on edge and let it remain.

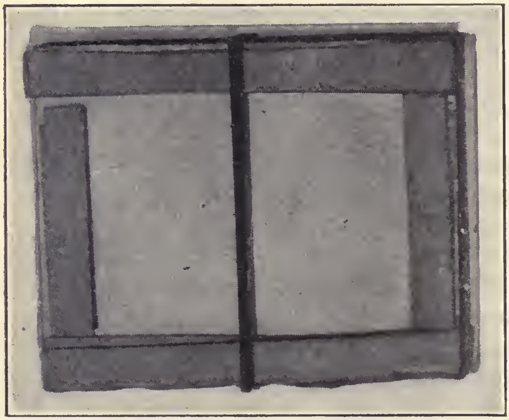


Fig. 168. A pocket garden.

5. Keep the paper moist. As soon as the seeds begin to grow, notice what happens. Notice the root hairs that form on the roots of the radish. In what direction do the roots grow? **6.** Turn the glass a quarter of the way around and allow it to stand over night. What happens to the roots? What to the stem? Turn the glass a quarter of the way around again and see what happens. **7.** Make drawings of the growing seeds from day to day.

Project 133 (I). **Planting a late spring garden.**

1. Plant seeds of some of the tender annual flowers, such as the aster, cosmos, four-o'clock, marigold, portulaca, and velvet flower. Since these are tender, the seeds cannot be planted until the danger of frost is past. In the northern section of the United States this is usually about the middle of May. **2.** Plant seeds of some tender vegetables, such as corn and beans, and some tomato plants.

Project 134 (G). **Raising lettuce sets in the schoolroom to take home and transplant for early lettuce.**

1. In the early spring, several weeks before the gardens are to be planted, get a box and fill it with garden soil. Water the soil. Smooth over the soil and take out the lumps. Sow the seeds about a quarter of an inch deep in rows six inches apart. **2.** Put the box in a warm place and keep the soil moist. Before the seeds come up, the box may be covered with paper to lessen the evaporation. **3.** After the plants are about one inch high, thin them out, leaving a plant every half inch. **4.** After the gardens are plowed and ready for planting, the plants should be divided among you and taken home to be set out in the gardens. You can also raise other plants, such as beets, cabbages, and tomatoes, in this way.

Project 135 (I). **Planting vines.**

1. In connection with this plan you may wish to read again what was said about vines on pages 7–10. **2.** Plant the seeds of some of the annual flowering vines, such as the balloon vine, cypress vine, gourd, nasturtium, morning-glory, and sweet pea. **3.** Which are the best vines to plant? What kind of support do vines require for climbing? Where is the best place for planting vines? **4.** If you have room in your garden, try a few hills of such vine crops as the summer squash, the bush muskmelon, and the cucumber. The first two mentioned do not grow long vines and so can be planted in a small garden. **5.** If you have a large garden, plant seeds of melons, pumpkins, or squash. (Fig. 164)

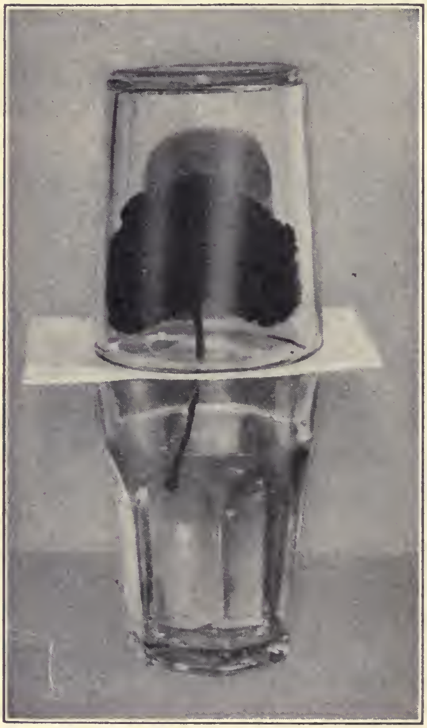


Fig. 169. Transpiration experiment.

Project 136 (G). Learning what one service of the leaf is.

1. Procure two tumblers and a large leaf or a cluster of leaves, either from some house plant or some plant outdoors. **2.** Fill one tumbler nearly full of water. On top of this put a piece of heavy paper with a small hole in the center. Through this hole push the stem of a leaf into the water below. Wipe the other tumbler dry and clean and invert it over the leaf. (Fig. 169) Place the tumblers in a sunny window and allow them to stand for a few hours. **3.** Notice what happens to the upper tumbler. What does the experiment show? How long does it take for the moisture to appear on the tumbler? This process is called transpiration.

CHAPTER XVIII

BIRDS

A. The Home Life of Birds

In the autumn you collected and studied bird nests. (See pages 80–83) We shall now observe the use that birds make of their nests.

After the nest is completed in the spring, the mother lays from four to seven eggs. The eggs of different birds vary in color; some are blue, some white, and some brown. The mother sits upon these eggs until they hatch, a period that varies from ten to fourteen days for most of our common song birds.

How much do young birds eat? Most birds are very helpless when they first come out of the egg and must be fed and cared for by their parents until they are able to look out for themselves. The chief work of the parent birds is to provide insect food for their young. Two points are of special interest in this connection: the large amount of food that young birds eat, and the rapidity with which they grow up. It is a common thing for parent birds to bring food to their young as often as two hundred times a day. Men who have weighed and watched birds have found that a young bird may eat its own weight of food in one day and

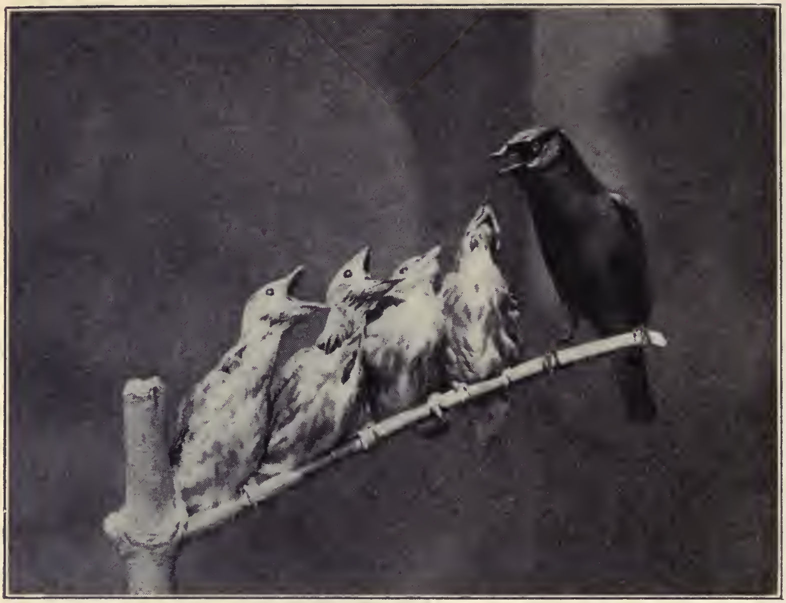


Photo by G. H. Trafton

Fig. 170. Family of cedar waxwings.

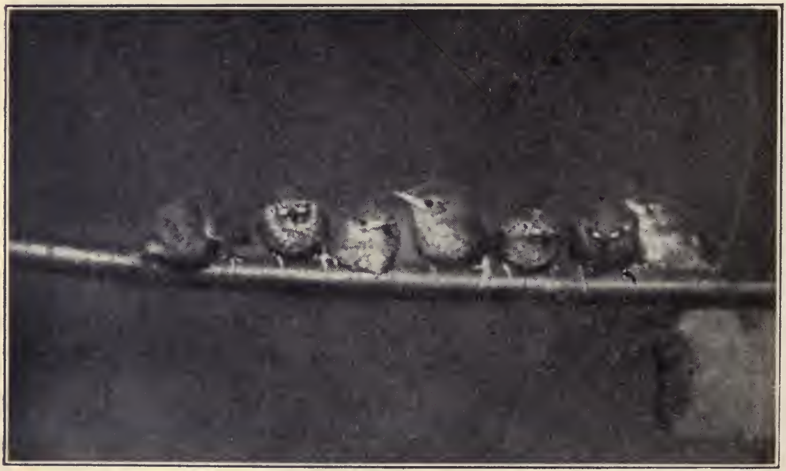


Photo by G. H. Trafton

Fig. 171. Family of young house wrens.

increase in weight fifty per cent during the same time. Suppose you weighed seventy-five pounds when you got up in the morning, ate seventy-five pounds of beefsteak in one day, and weighed one hundred and twelve pounds when you went to bed that night.

How fast do birds grow up? Because young birds eat so much food, they grow up very rapidly. In about two weeks they are full grown and almost as big as their parents. (Figs. 170 and 171) It takes boys and girls about eighteen years to grow up, as compared with two weeks for birds.

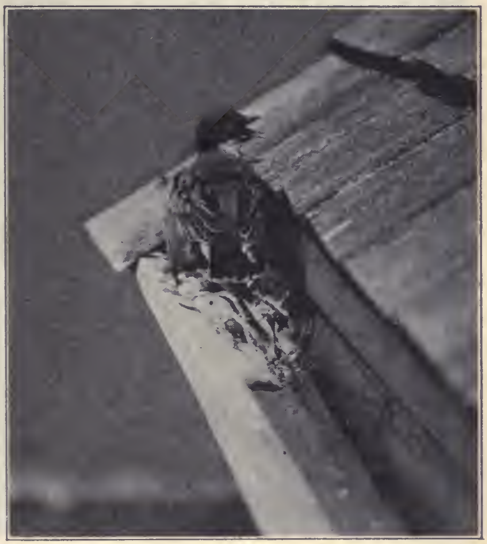


Photo by G. H. Trafton

Fig. 172. Kingbird protecting young from hot sun.

Although the mother does most of the work of hatching the eggs, both the father and the mother usually help care for the young. (Fig. 172) After the young birds leave the nest, they have a brief period of schooling in which they are taught such lessons as how to fly and how to find food. Very soon they are left to look out for themselves. Some birds, like the robin, begin at once to rear a second brood of young; and the English sparrow may rear two, or three, or more broods in one season.

The peculiar nesting habits of the cowbird. One of our common birds, known as the cowbird, has very

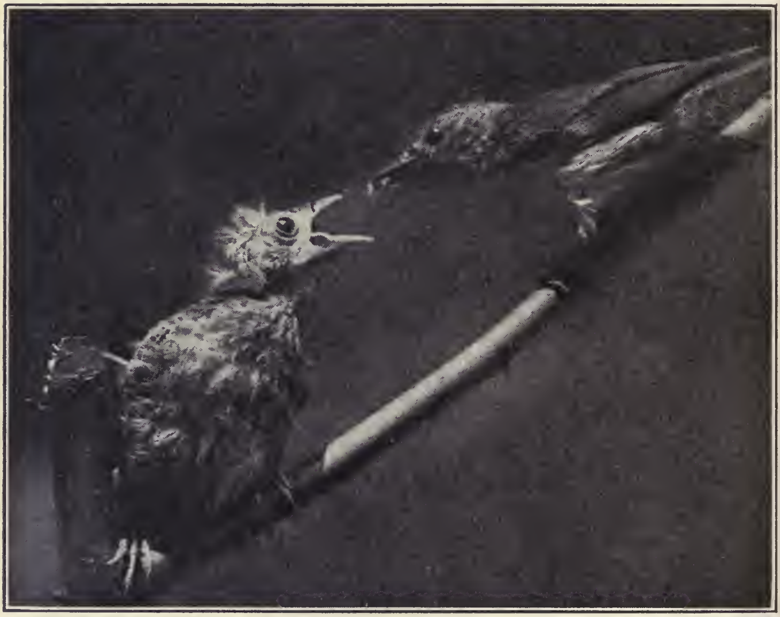


Photo by G. H. Trafton

Fig. 173. Mother redstart feeding a young cowbird much bigger than herself.

peculiar nesting habits. This bird never makes a nest of her own, but lays her eggs in other birds' nests. The eggs are hatched and the young birds reared by the foster mother. In many cases the cowbird lays her eggs in the nest of a bird smaller than herself. As a result, the young cowbird is bigger than the other young birds and so gets more food and grows faster. Frequently the other birds are starved or pushed out of the nest by the young cowbird. When the cowbird is full grown, in many cases it is bigger than the foster mother. As a result you may sometimes see one of these little mothers feeding a bird much bigger than herself. (Fig. 173)

There is one little bird, the yellow warbler, that has found a way of fooling the cowbird. When the yellow warbler finds a cowbird's egg in her nest, she has been known to build another nest on top of the first and to lay her eggs in the second story. (Fig. 174)

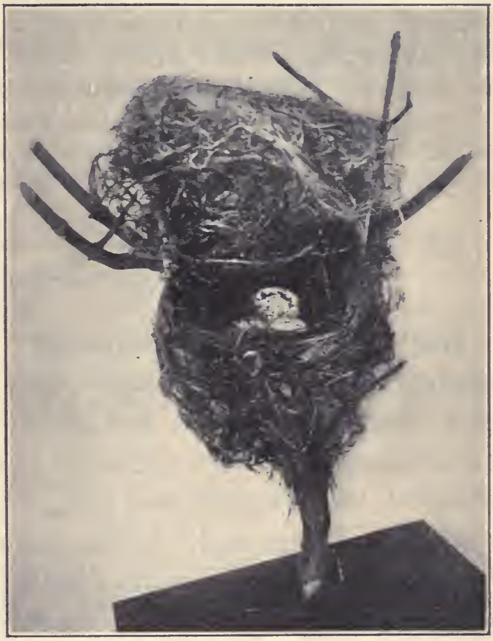


Fig. 174. Two-storied nest of yellow warbler, showing how this bird fools the cowbird.

Project 137 (G). **Observing how often birds feed their young.**

1. Find some nest with young birds in it that you can easily watch without disturbing the parent birds. 2. Decide on the time of day in which it is best to

watch the nest. Then divide up the time so that each one of you will watch the nest for a short time, fifteen minutes or a half hour, as the case may be. **3.** Every time that either of the parents brings food to the young, make a mark on a piece of paper. Write down the kind of food, if you can see what it is. If you can tell the father and mother apart, write *f* or *m* for each visit. **4.** Add all your results together and see how many times the parents come. What was the average number of times per hour? At this rate, how many times would they feed their young in a day from sunrise to sunset?

B. Songs of Birds

Why are bird songs interesting? Songs of birds are interesting for two reasons: first, because they help us to identify the bird; and second, because they may be pleasing just as are the songs of some people. How pleasant the songs of the first robins are when they return in the spring! As the other birds come back, they add their voices to the chorus till the climax of the song season is reached about the middle of May. From this time on the birds gradually stop singing, till by the Fourth of July the song season is nearly over, although a few birds continue to sing even after this time.

Birds begin to sing in the early morning, even at daybreak, and are in full chorus by sunrise. They gradually stop singing during the morning, and their song period for the day is nearly over by the middle of the forenoon. Then they sing again in the late afternoon, although not so much as in the morning. Singing is done only by the father birds and is connected with the mating and nesting season.

The musical quality of birds' songs varies greatly. Some songs are only harsh noises, while others are composed of very pleasing and harmonious notes. The songs of some birds sound so much like certain syllables that the birds have been named from them, such as the chickadee (Fig. 175), bobwhite, bobolink, whippoorwill, and phœbe. It is easy to imitate the songs of these birds. Among the birds that have beautiful songs are the thrush, song sparrow, vesper sparrow, goldfinch, house wren, brown thrasher, and catbird.

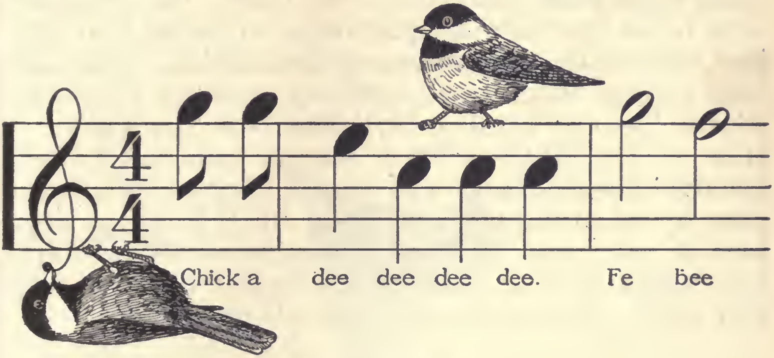


Fig. 175. Song of chickadee.

It is worth while to make plans to go out to hear these birds sing. We should distinguish between the songs of birds and their call notes. The call notes may be considered the language of birds. These notes are given by both the father and the mother birds and are used during all times of the year. They express certain feelings, such as hunger and fear. Notice the different call notes of the robin. One observer has recorded twenty-seven distinct call notes of the crow.

Project 138 (I). Learning to recognize birds by their songs and to imitate them.

1. The songs of birds make a very convenient means of recognizing our bird friends, because you can hear birds even when you cannot see them. **2.** Start first with birds that have simple songs, sounding like syllables, such as the chickadee and the phœbe. When you hear a song, listen to it carefully, and see whether it sounds like any words or syllables that you know. Is there variety to the song or does it consist of just one syllable repeated over and over? Try to imitate the song by whistling the syllables. **3.** If different members of your class can learn to imitate different birds, you might give a little entertainment on bird songs and invite your parents or your school friends.

C. THE TRAVELS OF BIRDS

How far do birds migrate? Bird *migration* is one of the most curious of bird habits. When birds return in the spring, you probably wonder where they have been all winter. Some birds migrate only a few miles, perhaps only to the next state; other birds go to the southern states; and still others go to South America, some to the northern and some to the southern part of that continent. (Fig. 176) The following table shows where a few common birds live during our winter. Consult a map of North and South America while reading this list.

Bird	*Where Found during our Winter*
humming bird	Panama
Baltimore oriole	Columbia
rose-breasted grosbeak	Ecuador
kingbird	Bolivia and Peru
bobolink	Paraguay
barn swallow	Argentine
nighthawk	Chili and Argentina

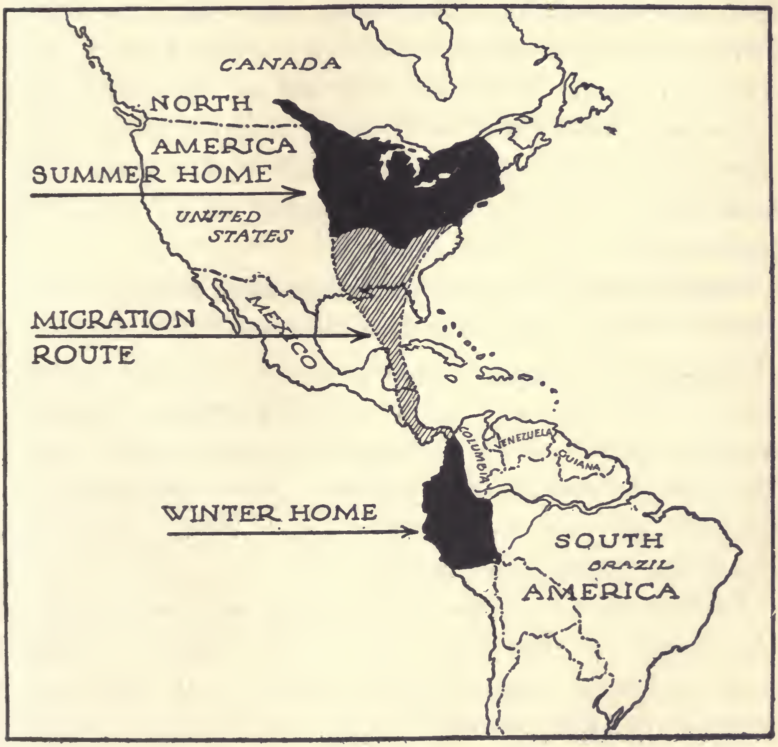

CANADA
NORTH
AMERICA
SUMMER HOME
UNITED STATES
MIGRATION
ROUTE
MEXICO
COLUMBIA
VENEZUELA
GUIANA
WINTER HOME
SOUTH
BRAZIL
AMERICA

Fig. 176. Homes of scarlet tanager.

There is one bird, the arctic tern, that travels almost all the way from the south pole to the north pole to nest, and then back again, a total distance of about twenty-two thousand miles a year.

How do birds find their way? When birds make such long journeys as some of them do, we naturally wonder how they travel such long distances without being lost. There are a number of landmarks that help birds to find their way. Some of these are the Atlantic coast line, the Appalachian Mountains, and the Mississippi River, all three of which extend in a general north-and-south direction. However, they are not the only means by which birds find their way. Experiments have shown that some birds have a sense of direction which leads them even when they are going on a journey for the first time in a new country.

How do the kinds of birds change from season to season? In observing birds you will notice that the kinds of birds you see at one season of the year are not the same kinds that you see at another season. For example, you do not see the same birds during the winter that you do during the summer. These differences in bird life are due to the migration of birds; they are constantly coming and going.

Birds may be divided into four groups according to the length of time they stay in one place. Permanent residents remain in one locality all the year; summer residents remain during the summer; winter residents remain during the winter; and transient visitants remain only a short time in the spring and fall.

The birds that belong in each group vary with the locality. Birds that are summer residents in one place may be permanent residents in places farther south. Following are a few permanent residents found in the latitude of New York City: bobwhite, chickadee, crow, goldfinch, bluejay, white-breasted nuthatch, and downy woodpecker. Examples of winter residents in this same latitude are the brown creeper, junco, white-throated sparrow, and tree sparrow.

The table on page 286 gives the dates of migration for forty common birds in the latitude of New York City, arranged in the order of their arrival in the spring, as found in Chapman's *Handbook of Birds.* This list may help you in making a study of the spring birds, as by it you may learn about when to expect a bird back.

Project 139 (G). **Keeping a spring calendar of the dates when birds return.** (**Fig. 177**)

1. First, procure a large piece of heavy paper. Make it into an attractive chart by putting some decorations across the top or down the sides. You may cut out colored pictures of birds and paste them on the chart or draw outlines of birds on the chart and color them. **2.** Mark off the space in the middle of the chart into three columns as follows:

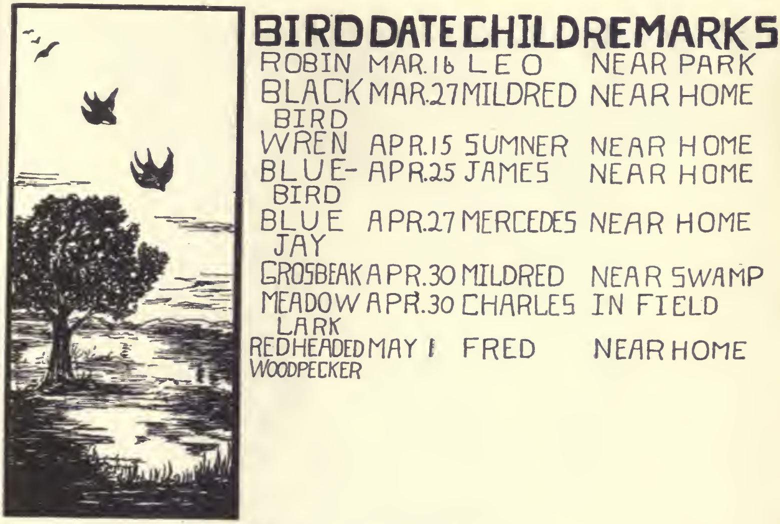
BIRD CALENDAR

Name of bird	Date first seen	First child reporting

Forty Common Summer Birds
(Latitude of New York City)

Name	Date of arrival	Date of departure
song sparrow	Feb. 15–March 10	Nov. 1–30
flicker	Feb. 15–March 10	Nov. 1–30
crow blackbird	Feb. 15–March 10	Nov. 1–30
red-winged blackbird	Feb. 15–March 10	Nov. 1–30
robin	Feb. 15–March 10	Nov. 1–30
bluebird	Feb. 15–March 10	Nov. 1–30
phœbe	March 10–20	Oct. 20–30
meadowlark	March 10–20	Nov. 1–30
cowbird	March 10–20	Nov. 1–30
kingfisher	March 20–31	Nov. 1–30
mourning dove	March 20–31	Nov. 1–30
field sparrow	March 20–31	Nov. 1–30
vesper sparrow	April 1–10	Nov. 1–30
chipping sparrow	April 1–10	Nov. 1–30
barn swallow	April 10–20	Oct. 1–10
chimney swift	April 20–30	Oct. 1–10
towhee	April 20–30	Oct. 20–30
purple martin	April 20–30	Sept. 20–30
ovenbird	April 20–30	Oct. 1–10
house wren	April 20–30	Oct. 10–20
brown thrasher	April 20–30	Oct. 10–20
catbird	April 20–30	Oct. 10–20
wood thrush	April 20–30	Oct. 1–10
cuckoo	May 1–10	Oct. 1–10
nighthawk	May 1–10	Oct. 1–10
humming bird	May 1–10	Sept. 20–30
kingbird	May 1–10	Sept. 20–30
Baltimore oriole	May 1–10	Sept. 10–20
bobolink	May 1–10	Oct. 1–10
indigo bunting	May 1–10	Oct. 1–10
rose-breasted grosbeak	May 1–10	Sept. 20–30
scarlet tanager	May 1–10	Oct. 1–10
red-eyed vireo	May 1–10	Oct. 10–20
warbling vireo	May 1–10	Sept. 20–30
yellow warbler	May 1–10	Sept. 10–20
Maryland yellowthroat	May 1–10	Oct. 10–20
redstart	May 1–10	Oct. 1–10
veery	May 1–10	Sept. 20–30
wood pewee	May 10–20	Sept. 20–30
marsh wren	May 10–20	Oct. 10–20

3. Whenever a child sees a bird, he reports it to the teacher, who puts the name down on the calendar. **4.** In keeping the calendar, you should all follow one important rule: The teacher is not to put down the name unless she is quite sure that you have seen the bird in question. It is very easy to make mistakes in seeing and describing birds. You should be able to give a good description of the bird, and you should expect the teacher to question you very closely about it so that she can be sure that you have not been mistaken. In case of doubt, do not ask the teacher to put down your name, but look again to make sure. Let it be an honor to get your name on the calendar. The teacher is the umpire of this game, and you must all help her to carry out the rules fairly. The name of each bird is put down but once.



BIRD	DATE	CHILD	REMARKS
ROBIN	MAR.16	LEO	NEAR PARK
BLACK BIRD	MAR.27	MILDRED	NEAR HOME
WREN	APR.15	SUMNER	NEAR HOME
BLUE-BIRD	APR.25	JAMES	NEAR HOME
BLUE JAY	APR.27	MERCEDES	NEAR HOME
GROSBEAK	APR.30	MILDRED	NEAR SWAMP
MEADOW LARK	APR.30	CHARLES	IN FIELD
REDHEADED WOODPECKER	MAY 1	FRED	NEAR HOME

Fig. 177. Bird calendar.

D. THE PRACTICAL VALUE OF BIRDS

Of what use are birds? Besides giving us a great deal of pleasure on account of their interesting ways, birds are also of great practical value to the farmer and gardener. If you have ever planted a garden, you know that the two enemies you fought were insects and weeds. The insects eat part of the garden plants and the weeds crowd others out. On a large scale over the United States insects do a great amount of harm to the crops that the farmers raise. A study of the habits of birds has shown that they are of great practical value because they eat a great many insects, weed seeds, and rodents (rats and mice).

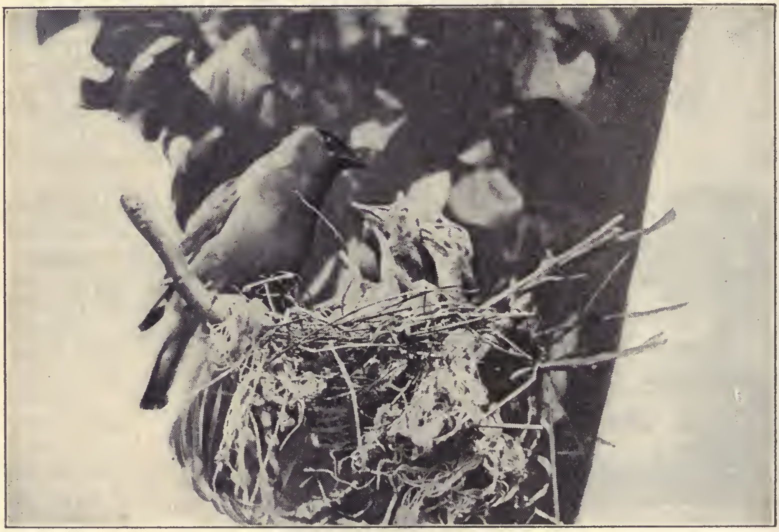


Fig. 178. Cedar waxwing feeding young.

One group of birds, like the oriole and wren, live almost entirely on insects, while another group, like the song sparrow and mourning dove, eat both insects and weed seeds. Men who have watched birds very carefully have learned that a bird eats a great many insects in a day. For example, one man noticed that a chickadee ate four insects in a minute and a scarlet tanager ate thirty-five caterpillars in a minute.

Not only do birds eat many insects in a day, but they feed on many different kinds of insects. For example, robins are known to feed upon two hundred twenty-three different kinds of insects. It is also known that at least twenty-six different kinds of birds feed on the potato beetle that does so much harm to the potato plant, and that eighty-eight kinds of birds feed on the cutworm that harms garden plants.

Birds also eat many weed seeds in a short time. A bobwhite that was kept in captivity was observed to eat 12,000 seeds of pigweed one day, and 15,000 seeds of lamb's-quarters another day. The hawks and owls do a great deal of good in destroying rats and mice, which do much harm in the fields, barns, and house.

On the other hand, it is true also that birds do some harm. Some, like the catbird and robin, eat a little cultivated fruit; blackbirds eat wheat and corn; the sapsucker injures trees by boring holes and sucking the sap; and some hawks and owls eat chickens. On the whole, however, the amount of harm done is very small compared with the vast amount of good that birds do. Therefore, most of our birds should be protected both for their practical value in destroying harmful pests and for the pleasure which their study gives to many people.

E. Bird Houses

Why should we make a bird house? If a pair of birds occupies your house, you will enjoy watching them build their nest and feed their young.

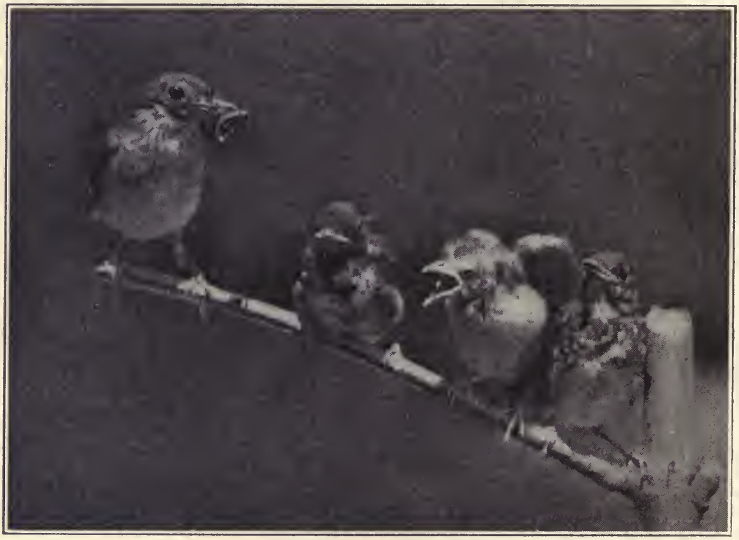


Photo by G. H. Trafton

Fig. 179. A Wilson thrush feeding young. A cowbird is the middle one of the three young.

These birds often become so tame that a person may stand close to them without frightening them. Furthermore, if you have a garden, the birds will help you destroy the insects that attack your vegetables.

And it is a real help to the birds to put out houses for them. Many years ago when the country was covered with trees, no bird had to look very far for a good place to build its nest. But to-day, as towns grow larger and new houses are built, many trees, containing the cavities in which some birds nest, are cut down. As a result, there are few places in such localities where birds of this type can nest unless houses are put up for them.

The first thing to do in building a bird house is to decide on the kind of bird you want to make the house for and then adapt it to that particular bird. Not all birds will use nesting houses. Only those which naturally build their homes in cavities, such as the wren, bluebird, and martin, will come to them.

How should the house be built? After you have decided on the kind of bird for which you wish to build your house, you should decide on the kind of house that you want to make, the materials to be used, and the size and shape of the house. Wood, either in the form of plain boards or of slabs with bark on them, is the material most commonly used. Good bird houses can also be made out of old tin cans. The size of the house depends upon the size of the bird; the larger the bird, the larger the house. For birds like the wren and the bluebird, which use houses most commonly, the shape of the house does not matter much if the other conditions are right. Sometimes it is well to build the house so that it looks like a real house with a roof. It does not make the house any more attractive to the birds but it sometimes makes it more of an ornament to the yard.

How should the opening be made? One of the most important things to consider is the door, or opening, by which the bird enters the house. Special attention should be paid to the size and location of this door. The size depends upon the size of the bird; the bigger the bird, the bigger the opening. It should be located in the upper half, like a second story window, not like a door on the first floor. This high location protects the young birds from cats and keeps them in the house until they are big enough to leave the nest. If the door is too far down, the young may fall out before they are full grown. For a wren the hole should be one inch in diameter, and for a bluebird an inch and a half.

How should the house be put out? Another thing you should consider while building the house is a means of fastening it to some tree or post. One of the simplest ways is to nail a narrow cleat to the back of the bird house and bore a small hole at the top and bottom of the cleat, through which nails can be driven without splitting it. After the house is finished, it may be put out on a tree or post. It should not be put in dense shade, such as is made by many trees together. However, it may be put on trees that stand out by themselves, like shade trees. From six to ten feet is the best height. The house should be ready for use by the time the birds arrive in the spring.

Project 140 (I). Making a nesting house for wrens.

1. A wren is a very small bird, and so its house and doorway should also be small. The hole should be one inch in diameter, and the dimensions of the house may vary from four to six inches. In the northern part of the United States the wren returns about the last of April. Following are directions for making two simple wren houses: **2.** A wren house can be easily made from a chalk box. (See Fig. 180) Bore a one-inch hole in the cover near the top, then nail it on the box. Nail a piece of lath on the back for fastening the box up. If you wish, you can put on a roof, as shown in Figure 180. If the house is painted, it will look better and last longer. Either green or brown paint may be used.

3. A wren house can also be made out of a tomato can. (Fig. 181) First knock off the jagged edge of the cut end of the tomato can. A coffee can is also good for the purpose. Place the open end of the can on a thin piece of board and draw a line around it. Bore a one-inch hole near one side. Fit this circle, after it is cut out, into the end of the can and fasten by driving tacks into it through the tin. It can be fastened up by a wire wrapped around the can, or a narrow cleat may be fastened to the back of the can. Put the can in such a position that the opening is in the upper half of the circle.

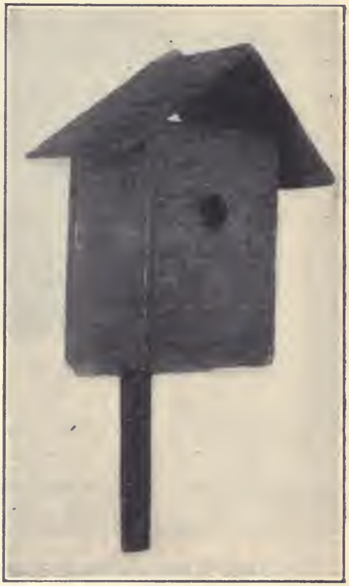


Fig. 180. Wren house made from chalk box.

Project 141 (I). Making a nesting house for bluebirds.

1. The house for bluebirds should be larger than that for wrens, and the hole larger. The house should be about six inches the narrow way, and from ten to twelve inches high.

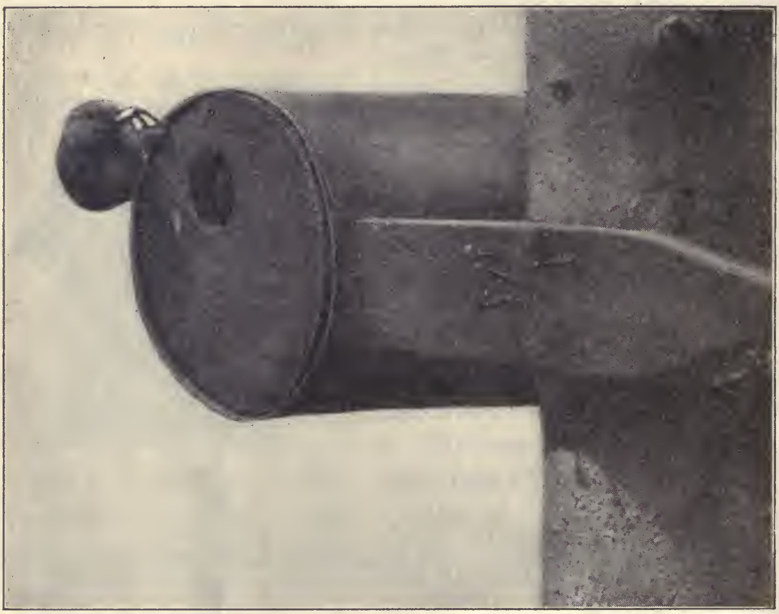


Fig. 181. Wren nesting in a tomato can. Five families of young wrens were reared in this can during four seasons. Note the position of the wren's door, of the can against the tree, and of the support that holds it in place.

The bluebirds are among the first birds to return in the spring, arriving in the northern part of the United States about the middle of March. (Refer again to the table on page 286. How does the bluebird compare with the wren?) Therefore you should start to make your house early.

2. Figure 182 shows the different parts of the house and the size of each. Cut pieces of board to correspond with the size and shape shown in the figure. The dimensions here given for the floor are for a half-inch board. You can use any thickness of board and then finally make the floor to fit. **3.** Then nail the pieces together, as shown in Figure 182.

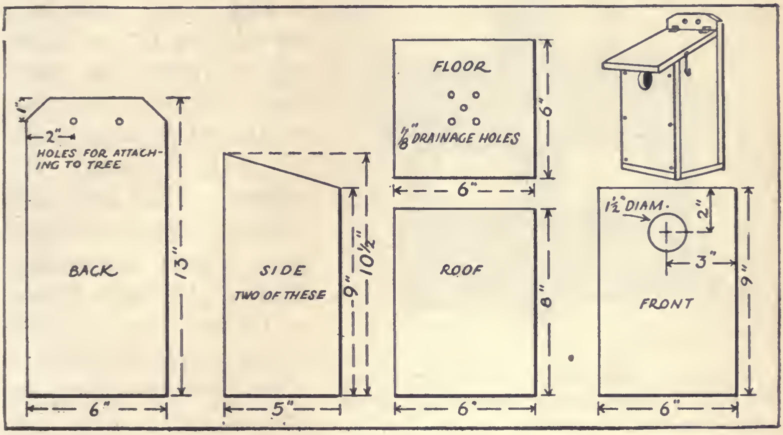

1"
2"
HOLES FOR ATTACHING TO TREE
BACK
13"
6"
SIDE
TWO OF THESE
9"
10½"
5"
FLOOR
⅛" DRAINAGE HOLES
6"
6"
ROOF
8"
6"
1½" DIAM.
2"
3"
FRONT
9"
6"

Fig. 182. Plans for a bluebird house. The dimensions for the plan of floor are for half-inch board.

4. You will notice that the cover is fastened with a hinge and a clasp. The purpose of this is to allow the box to be opened and closed easily. When sparrows use the house, one way to try to get rid of them is to lift the cover and remove the eggs. Sometimes, but not always, the sparrows leave the house, thus giving the bluebirds a chance to come in. If you wish, you can nail the roof on instead of using a hinge and a clasp. The house may be painted or stained green or brown. **5.** Put up the house in some open place on a post or a pole from six to ten feet high.

Project 142 (I). Making a nesting house for robins.

1. Robins will not use closed houses, but they have been known to use an open house of the porch type. Such porches may also be used as feeding shelters for birds during the winter. **2.** Figure 183 shows a simple house of this kind. The floor should be from six to eight inches on each side. Nail a narrow cleat, such as a piece of lath, around the edges. **3.** At each corner fasten a small post about six inches high. On these fasten a board for a roof. On the back fasten a cleat for hanging up the house.

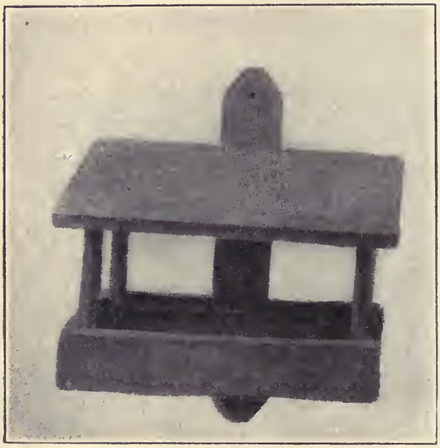


Fig. 183. Open house for the robin. May be used in the winter as a feeding tray for the birds.

Project 143 (I). Making a fountain for the birds.

1. Birds use water for two purposes, drinking and bathing. A bird fountain may offer many interesting chances to watch birds. **2.** These fountains may be very simple. Get a common tin pan three or four inches deep and a foot or so across. Fill this with water and in the center place a brick on its narrow edge. **3.** Place the pan in some shady place where it will be protected from cats. It may be placed on the ground or on a shelf attached to a tree. **4.** The water should be changed often enough to keep it cool and clean — about once a day.

F. Projects in Bird Study

Project 144 (G). Making colored outlines of birds.

1. You will need some colored pictures from which to color the birds. You may find these in bird books; you may get separate pictures, as when you join the Audubon Club; and you may make collections of pictures. You may get them free from the Singer Sewing Machine Co.; and in each package of the Arm and Hammer brand of soda you will find a small picture. You may send to the manufacturers of this soda and get a set of thirty pictures for three two-cent stamps; they issue four sets. **2.** There are three ways in which you can get outlines for coloring. First, you can get them all made ready to color, as with the pictures given you when you join the Audubon Society; second, you can trace them; and third, you can draw them free hand. You might try each method and see which you like best.

3. Following is a simple way of tracing: Procure two pieces of paper, one of thin paper and another of the heavier paper on which you wish to make your colored picture. Put the thin paper over the picture of the bird and trace the outline. Then place the paper with the tracing side down on the heavy paper. Rub a pencil back and forth on the back of the thin paper. Enough of the pencil mark on the other side will be rubbed off to make an outline on the heavy paper. **4.** You may use either colored crayons or water colors in making your picture. Keep two things in mind as you color the outline: First, select the right color; and second, put it on the proper part of the bird.

Project 145 (I). Learning to identify some common birds.

1. Most of our common birds have some one or two noticeable habits or colors, which we shall call field marks, by which they may be identified. If you know what these field marks are, you can name birds more easily. The following table gives the field marks of twenty common birds.

Name of bird	*Field marks*
red-winged blackbird	bend of wing red.
chickadee	cap and throat black.
cowbird	head coffee brown, body black.
flicker	under side of wing yellow; in flight a white spot where tail joins body; flight up and down.
goldfinch	yellow body; black cap, wings, and tail; flight up and down.
rose-breasted grosbeak	breast rose; bill very large; in flight black and white conspicuous.
blue jay	back bright blue; head crested; size of robin.
kingbird	tip of tail white.
purple martin	bluish black; constantly on the wing.
meadow lark	black crescent on yellow breast.
nighthawk	constantly on wing, high up in air; white spot on wing.
white-breasted nuthatch	on tree trunk *head downward;* black cap, gray back.
Baltimore oriole	orange and black.
chipping sparrow	small; cap bright brown.
English sparrow	big black patch (necktie) on throat.

Name of bird	*Field marks*
song sparrow	breast spotted.
chimney swift	long narrow wings; constantly on the wing, high in air.
yellow warbler	yellow breast spotted with bright brown.
downy woodpecker	on tree trunks; back black and white.
house wren	very small, brown.

2. Copy the above list in your notebook, leaving a little space after each bird. **3.** See how many of these birds you can find during the spring. As soon as you identify one, put a check in front of the name in your notebook together with the date and write anything of interest that you observed about the bird as regards size, color, or habits. **4.** If you find any birds not in this list, write their names at the end of your list.

Project 146 (I). Observing the habits of one kind of bird.

1. In the early spring select some bird that you are interested in and see how much you can learn about it from outdoor observation. Record the results of your observations in your science notebook.

2. Following are suggested some points to aid you: *Size.* How does this bird compare in size with the robin or the English sparrow? *Colors.* What are its most striking colors as you see it from a distance? When you see it on the wing? When you see it closer, notice the color of the back and the breast, and, if you can, of the wings and tail. *Flight.* Is there anything about its flight that is different from that of the other birds? *Song.* Describe the song. Is there much variety to it? Is it musical? Is it loud or soft? Can you imitate it? *Nest.* If you find its nest, notice where it is located. How high from the ground is it? *The nestlings.* After the young hatch out, sit quietly near the nest and count the number of times that the birds feed their young in a certain time. How many times in an hour? How old are the young when they leave the nest?

Project 147 (G). **Studying the habits of the "Birds of the Air."**

1. There is a group of birds which, during the day, are so constantly on the wing that we may call them "Birds of the Air." They are listed in the table below. **2.** In order to make a record of what is seen a large piece of heavy paper, two or three feet square, should be procured and marked off like the table below. If you can procure some colored pictures of these birds, you might paste them around the edge of the chart. **3.** Watch as many of these birds as you can find and see how many of the points called for in the table you can discover. Whenever you do observe any of these facts, report to the teacher so that she can write the facts in the proper space in the table.

BIRDS OF THE AIR

Names of birds	Colors	Length	Method of flight	Shape of wings	Location of nest	Description of song
barn swallow						
bank swallow						
tree swallow						
purple martin						
chimney swift						
night-hawk						

4. Notice under *colors* the conspicuous color markings by which each bird can be told from the rest; under *length* the measurement in inches from the tip of the bill to the tip of tail; under *method of flight* how the chimney swift and night hawk differ from the swallows. **5.** At the end of the term copy the table as filled out into your science notebook. **6.** You can work out a similar table for the study of other groups of birds, such as: "Birds of Shade Trees," or, "The Woodpecker Family."

Project 148 (G). Arranging the birds that you know according to color.

1. Near the close of the spring term the following exercise may be used to review your knowledge of birds. **2.** The following table should be put on the board by the teacher or by one of the children:

Birds Marked with

Red	Blue	Yellow	Brown	Black	Gray

3. Recall all the birds you know and write their names in the proper columns. When a bird has more than one color, place it according to its brightest color. **4.** After the table is filled out, copy it in your notebook. **5.** Instead of waiting till the end of the term and making this a review exercise, you may start this early in the spring and write down the names of the birds as they return.

Project 149 (G). Discussing some bird problems.

1. Is the English sparrow a nuisance or is it of value to us? **2.** Does the crow deserve protection? **3.** Of what use is the robin? **4.** Which is greater, the good or the harm that hawks do? **5.** In what ways are the swallows fitted for living so much of the time on the wing? **6.** How may the different swallows be told apart? **7.** How may the chimney swift be distinguished from a swallow? **8.** How may the goldfinch be distinguished from the yellow warbler? **9.** How are the habits of the English sparrow different from those of the other sparrows?

G. BIRD CLUBS AND OTHER ACTIVITIES

Project 150 (G). Forming a Junior Audubon Society. (Frontispiece)

1. Junior Audubon Societies are clubs of boys and girls who are interested in the study of birds. In 1925 there were about 7,225 clubs with a membership of about 300,000 boys and girls in the United States. Perhaps you and your classmates will be interested in forming a bird club. You like birds; and it will be fun to form a club, elect officers, and hold meetings. **2.** Those who wish to join should bring ten cents to the teacher, who will send the money to the National Audubon Society, 1974 Broadway, New York City. Soon each of you will receive a bird button and six pamphlets, each of which contains a colored picture, an outline drawing of the bird in black and white, and a story about the bird. Although these six pictures would ordinarily cost thirty cents, by joining the club you get them for only ten cents. **3.** The first thing to do is to organize your club. You may elect the following officers: president, vice-president, secretary, treasurer, and a program committee, of which the teacher shall be a member. The purpose of the program committee is to arrange for the meetings of the club.

4. Following are some suggestions of things you can do at your meetings: *a.* Color the outlines that come with the bird pictures. *b.* Read the story about some one bird. *c.* Write a story about some one bird. (Project 146) *d.* Have a robin meeting, at which you tell of all the interesting things that you have seen or heard about the robin. (Or some other bird may be chosen.) *e.* Take a hike to study birds. *f.* Play bird games with colored pictures. (Project 152) *g.* Discuss some of the problems suggested in Project 149. *h.* Make bird houses. (Projects 140–142) *i.* Arrange a bird-day program.

Project 151 (G). Writing a bird story for *Bird Lore.*

1. There is a bird magazine called *Bird Lore* that publishes many interesting stories about birds. It contains a school department, and stories written by school children are often printed there. Get a copy of *Bird Lore* and have someone read to the class the stories written by the school children. **2.** Do you suppose that there is anyone in your class who can write a story good enough to be published in *Bird Lore?* Each of you may write some bird story of things you have learned about birds by watching them, or about something you have done for birds, such as feeding them, or making nesting boxes, or giving a bird play. You might like to write about your Junior Audubon Society, if one has been formed in your school. **3.** Then the teacher will read these stories and pick out the best ones to send to *Bird Lore.* It would be something to be proud of, if you were to get a story with your name signed to it published in this magazine.

Project 152 (G). Playing games with colored bird pictures.

Game 1. The teacher holds up the pictures, one at a time, and the child who first names a bird correctly takes the picture and places it on his desk. The child who has the most pictures at the end of the game wins. A few pupils at a time can be selected to play the game.

Game 2. The teacher pins a picture on the back of a child and shows it to the class. The child asks questions until he guesses the bird. He then names some other child to take his place.

Game 3. Place the pictures around the room, with the names covered. The teacher asks some child to go to the board and pick out certain birds. The rest of the class watch to see whether he picks out the right picture. This child then calls on someone else to come and pick out another bird; and thus the game goes on.

Game 4. One child takes the pictures in his hand (the names being covered), and stands before the class. He holds up the pictures, one at a time, and names them. If he makes a mistake, the child who corrects the mistake then takes his turn in naming the pictures.

Game 5. Arrange the pictures around the room with the names covered. Write on separate slips of paper the names of birds and place them in a pile on the table. A child goes to the table and draws a slip, reads aloud the name of the bird, and then places the slip beside the picture of that bird. If he makes a mistake, the other children correct him.

Game 6. This game may be played like a spelling match. Two captains choose sides. The two sides line up in two rows. The teacher shows the pictures in turn to each side, whose members take turns in naming the birds. If a child misses, he goes to the other side. The side that has the greater number of pupils standing after the pictures have all been named wins the game.

Try to make up some more bird games.

CHAPTER XIX

FLOWERS

Flowers are enjoyed by everyone, from the youngest child to the oldest adult. They speak a language that all can understand. Their delicate fragrance and beautiful colors appeal to us all. They seem appropriate on nearly all occasions.

What are the parts of a flower? An ordinary flower consists of four parts. (Fig. 184) On the outside is a row of leaflike objects called *sepals,* which, taken together, are called the *calyx.* Inside of these are the *petals,* which, taken together, are called the *corolla.* Inside the petals are the *stamens,* each made up of two parts: the *anther,* or pollen box, and the *filament,* or stem. In the center are the *pistils,* each made up of three parts: an *ovary* at the base, a *stigma* on top, and a *style* joining the ovary and stigma.

Each part of a flower is of use to the whole flower. The calyx serves as a sort of cup to protect the petals. The petals are useful in attracting insects. The anther bears a substance called *pollen,* and the ovary bears cells called *ovules.* These pollen grains and ovules unite and as a result of this union seeds are eventually formed.

Why do insects visit flowers? You have often seen butterflies and bees around flowers, and probably you have wondered why they come there. The story of how flowers and insects help each other is a very interesting one. Insects go to flowers to get food, of which they find two kinds, *nectar* and *pollen*. Nectar is a sweetish liquid found in certain portions of the flower. If you will look at the nasturtium or violet, you will find several little spurs called *nectaries*, which secrete nectar.

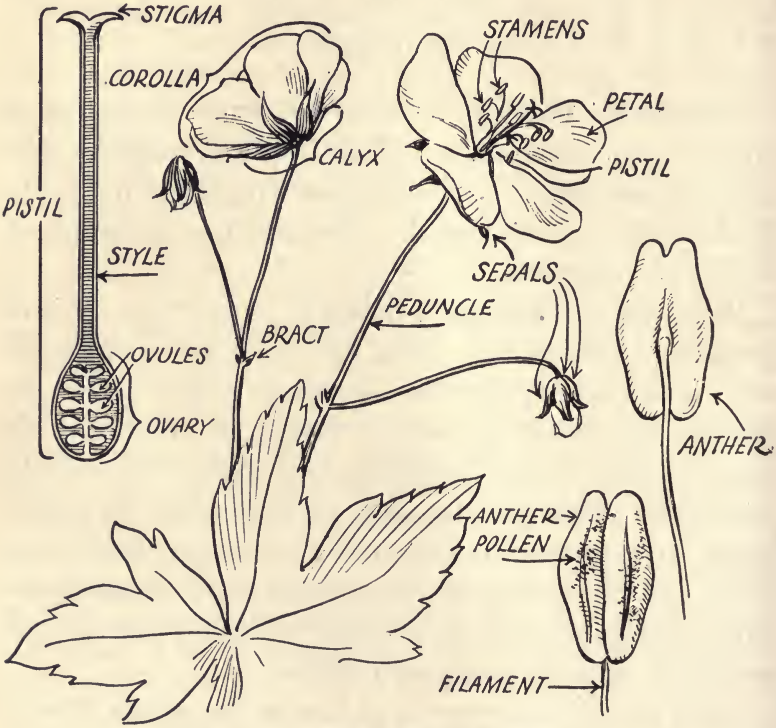

STIGMA
COROLLA
CALYX
STAMENS
PETAL
PISTIL
PISTIL
STYLE
SEPALS
PEDUNCLE
BRACT
OVULES
OVARY
ANTHER
ANTHER
POLLEN
FILAMENT

Fig. 184. A flower with parts named.

If you will break off the tip of one of these spurs, you will find inside a drop of liquid, which is the nectar. The butterflies and moths suck up this nectar by means of their long tongues. (Fig. 185)

Not all flowers contain nectar. Those that do have brightly colored petals and an odor, while those without nectar are dull colored and without odor. By instinct the insect is led to visit those flowers of bright color and strong odor. Thus you see that the same two features that make flowers attractive to you are the ones that serve to guide the insect to flowers to get food.

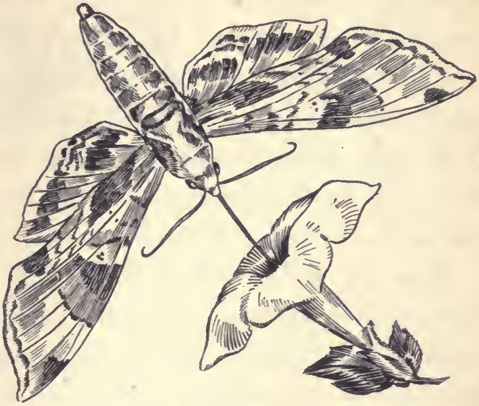


Fig. 185. Moth with its long tongue sucking nectar from a flower.

How do bees make honey? People sometimes say that bees get honey from flowers. This is not a correct statement, however, because the bees really get only nectar from the flowers, and from this nectar they make their honey. The nectar is sucked up by the bee into a honey sac in the bee's head. Here it is changed, made sweeter, and formed into a weak honey. This honey is deposited in the cells of the hive; it is still too watery to make good honey. The workers stand around the cells and fan them with their wings. Some of the water evaporates from the honey, which thus becomes thicker.

After the bees store the honey in the cells, people who keep bees take the combs and sell them. Sometimes the comb that holds the honey is sold with the honey. In other cases, the honey is thrown out of the cells by means of a machine and sold as a liquid honey; then the cells are put back into the hive, where they are again filled with honey. The first kind is called *comb honey* and the second *liquid honey*.

Another kind of food that some insects, like the bee, get from flowers is pollen. The bees gather this, pack it in little pollen baskets on their legs, and carry it to the hive, where it is taken off and made into a substance called beebread, which is fed to young bees.

How do insects help flowers? We have seen that flowers help insects by furnishing food. But how do the insects help the flowers? Everywhere in nature seeds are one of the usual means by which new plants are formed. They are the means you generally use in starting your garden. The purpose of the flower is to form seeds. The first step in forming seeds is for a pollen grain and an ovule to unite and form a cell. Later a seed is developed from this cell. Before these two parts can unite, it is necessary that they be brought together.

The insects help the flowers by bringing about *pollination* — that is, by carrying pollen from the anthers to the stigmas. The insects bring about this transfer unintentionally, as follows: When an insect, such as a bee, is visiting a flower to get nectar, it naturally moves about and brushes against the anthers. Some of the pollen is thus brushed off on to the bee's head and on to the hairs of its body. The bee goes to another flower carrying this pollen with it; and, as it visits the other flower, it hits against the stigma of the pistil and brushes some of the pollen on to the stigma, which is covered with a sticky substance that holds the pollen. Thus the insect is unintentionally helping the flowers by carrying the pollen from one flower to another of the same kind. (Fig. 186)

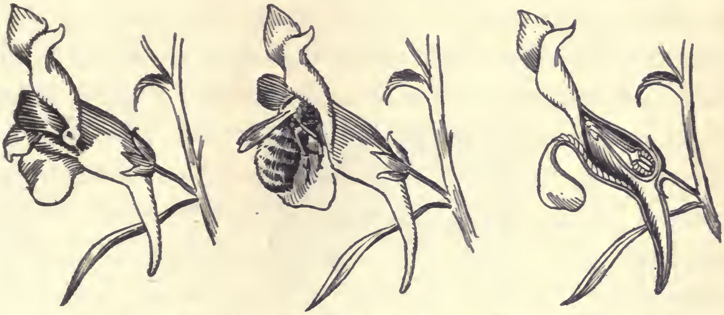


Fig. 186. Pollination of toadflax by bumblebee.

Probably some of you are wondering what will happen when a bee bearing pollen from apple blossoms visits a cherry blossom and leaves some of this pollen on the stigma of a cherry flower. The answer is that nothing happens as far as the formation of seeds is concerned; it is as though so much dust were sprinkled on the flower. Before seeds can be formed, pollen from one flower must be carried to another flower of the same kind, as from an apple flower to an apple flower and from a cherry flower to a cherry flower.

How do these visits of insects help mankind? Nor is this all of the story; not only do these visits of insects to flowers help both flowers and insects, but they also help us. At the same time that seeds are being formed, certain growths, called fruits, are also forming around the seeds; and many of these fruits are eaten by man. For example, following are the names of some of the fruits, formed around seeds, that we eat: apples, pears, peaches, plums, cherries, strawberries, blackberries, muskmelons, watermelons, cucumbers, pumpkins, and squash. If the insects did not pollinate these flowers and thus make the formation of seeds possible, no fruit would form. If you should tie a paper bag around a cluster of apple blossoms just before they open, so as to keep the insects away from the flowers and let it stay on for several weeks, no apples would form on them.

Thus you see the partnership between flowers and such insects as bees is a very helpful and wonderful one to all concerned. As a result, flowers are able to form seeds; bees get nectar and pollen for food; and we get many fruits and vegetables for foods.

Project 153 (G). Playing games with spring flowers.

You can play the same games with spring flowers that you played with the autumn flowers. (See pages 21–22)

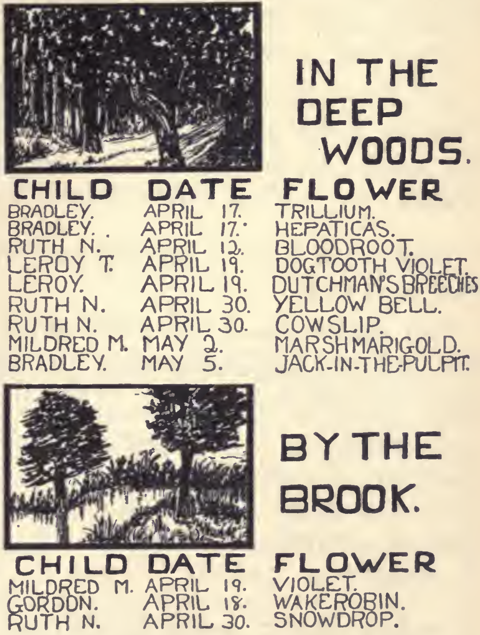
Project 154 (G). Making a calendar of the spring flowers.

1. Procure a large piece of heavy paper. Across the top put some attractive flower decorations in color, either by cutting out pictures or by making drawings with crayons. (Fig. 187) Copy the following headings:

Flower Calendar

Name of flower	Date brought in	Name of first child bringing it	Place where found

2. Whenever a new flower is brought in, its name is put on the chart and the columns filled out as indicated above.



IN THE DEEP WOODS.

CHILD	DATE	FLOWER
BRADLEY.	APRIL 17.	TRILLIUM.
BRADLEY.	APRIL 17.	HEPATICAS.
RUTH N.	APRIL 12.	BLOODROOT.
LEROY T.	APRIL 19.	DOGTOOTH VIOLET.
LEROY.	APRIL 19.	DUTCHMAN'S BREECHES
RUTH N.	APRIL 30.	YELLOW BELL.
RUTH N.	APRIL 30.	COWSLIP.
MILDRED M.	MAY 2.	MARSH MARIGOLD.
BRADLEY.	MAY 5.	JACK-IN-THE-PULPIT.

BY THE BROOK.

CHILD	DATE	FLOWER
MILDRED M.	APRIL 19.	VIOLET.
GORDON.	APRIL 18.	WAKEROBIN.
RUTH N.	APRIL 30.	SNOWDROP.

Fig. 187. Flower calendar.

Project 155 (G). **Noticing those characters of a flower by which it may be identified.**

1. The following outline for the study of flowers may be used with each flower you bring, or two flowers may be studied at the same time to see how they differ: *Color*. What are the chief colors? Do different flowers of the same kind differ in color? If more than one color is found on a flower, how are the colors arranged? *Size of flowers*. Determine just how much of the growth is one single flower. How big is this flower? As compared with the other flowers, is it large or small? *Arrangement of flowers.* How are the flowers placed on the stem? Do the flowers stand out separately or are they grouped in clusters? *The leaves.* Is there anything noticeable about the leaves as regards size or shape? *Size of plants.* About how tall is the entire plant?

2. Following is a list of a few spring flowers found in the eastern and northern parts of the United States.

anemone
bellwort
bloodroot
Dutchman's breeches
hepatica
jack-in-the-pulpit
squirrel's corn
toothwort
trillium
violets (purple, white, and yellow)
wild ginger
wild phlox

3. Copy the list in your notebook in one column. Find as many of them as you can. Put a check before the name of the flower and write the color after the name. **4.** Add as many others to the list as you can.

Project 156 (G). Discovering how the parts of flowers differ from each other.

Get specimens of any two kinds of flowers. Compare the parts of the flowers, one part at a time, and notice how they differ in regard to the following points.

1. Sepals — *a.* number, *b.* shape. 2. Petals — *a.* color, *b.* number, *c.* shape.

3. Stamens — *a.* number, *b.* appearance of anther, *c.* length of filament. 4. Pistils — *a.* number, *b.* length.

Project 157 (G). Reviewing the flowers you know by grouping them according to color and habitat.

1. In order to review the flowers that you know, it will be helpful to use the following tables. Copy them on the blackboard and fill them out according to their headings.

Flowers Grouped according to *Color*

Red	Yellow	Blue	Pink	White

Flowers Grouped according to *Habitat* or *Home*

Flowers growing				
In woods	In fields	In pastures	In swamps	By the roadside

2. Copy the lists in your notebook.

Project 158 (g). **Observing how insects pollinate flowers.**

1. These observations must be made, of course, outdoors where the flowers are growing. **2.** Watch one kind of flower for a few minutes. How many different kinds of insects come to the flower? Can you tell the names of any of them? **3.** What color is the flower? Do you find any nectar guides (streaks on the petals leading toward the center of the flower)? Can you find where the nectar is located? **4.** Has the flower an odor? Is it pleasant or unpleasant? Is it weak or strong? **5.** Watch one insect for a few minutes. Notice what it does. Can you see the tongue with which it sucks up the nectar? Watch it for a minute and count the number of different flowers it visits. Does it visit the same kind of flowers all the time or does it go to different kinds?

Project 159 (I or G). Observing the spring-blooming shrubs and garden flowers.

1. Many shrubs blossom in the spring and are very attractive at this time. For each shrub notice the color of the flowers. During what month do they blossom? Are the flowers fragrant? **2.** Notice also the leaves of the shrubs. What is the shape? How large are they? What sort of edges do they have? **3.** How tall is the entire plant? **4.** Following is a list of a few common shrubs found in the eastern and northern United States. Copy the list in your notebook.

Name	*Color of Flower*	*Date of Blossom*
bridal wreath		
dogwood		
elderberry		
flowering almond		
golden bell		
high-bush cranberry		
honeysuckle		
Japanese barberry		
lilac		
mock orange		
snowball		

5. Fill in the last two columns for as many shrubs as you can observe. Add the names of any others that you find. **6.** Which three shrubs do you consider the most attractive to have growing in your yard?

7. Find as many as you can of the following garden flowers: columbine, bleeding heart, crocus, daffodil, hyacinth, iris, lily of the valley, peony, tulip. Copy the list in one column on the left of a page in your science notebook and check them off as fast as you see them. After each name write the color of the flower. Add any other garden flowers that you find.

CHAPTER XX

TREES

Trees offer something of interest for each season of the year; in summer there is the green foliage; in autumn the colored leaves; in winter the arrangement of the branches; and in spring the opening of the buds.

Some people have the notion that buds suddenly appear on the trees in the spring just before they open. This is a mistaken idea, however, for the buds began to form the previous spring as soon as the leaves appeared on the trees. These buds were fully formed by early summer.

How do buds differ from one another? The buds themselves are interesting even before they open. They differ from each other in shape, size, color, and location. (Fig. 89, page 141) While nearly all buds are pointed, some are more slender than others; and they differ greatly in size. Some, like those of the coffee tree, are so small that one must look closely to see them at all; others, like those of the horse-chestnut, are very large and conspicuous. Some buds have only one scale covering them, while others have many scales. Most buds are located at the base of a leaf just above the leaf scar and so show the same differences in arrangement on the twig that leaves do; that is, they are either *opposite* or *alternate*. Buds are also found at the tips of twigs. These are called *terminal buds*.

A bud is really a little stem crowded into a small space and protected for the winter. If a bud is opened carefully, on the outside may be found the scales, sometimes covered with a sticky substance, and inside the small, partially-developed leaves and flowers. According to what they contain we may distinguish leaf buds, flower buds, and mixed buds. In some trees the flower buds open first (Fig. 188), in others the leaf buds, while

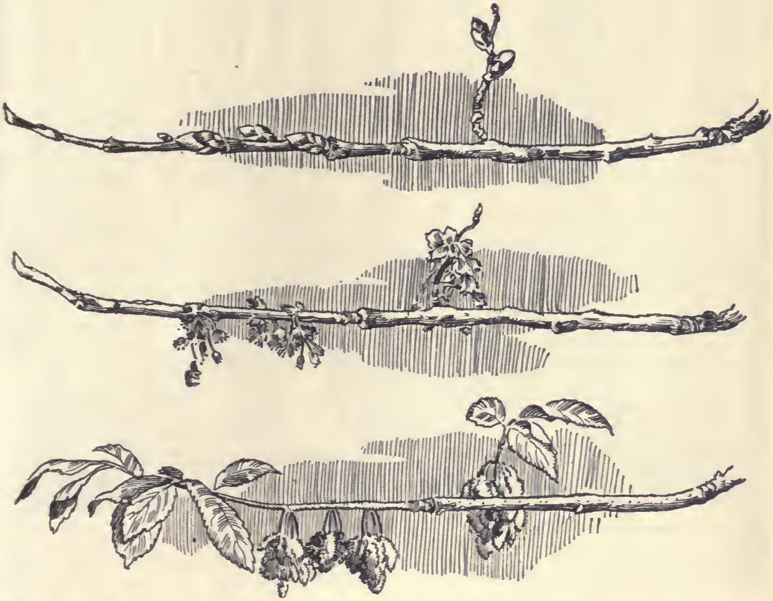


Fig. 188. Opening of elm buds. From Brownell: *Laboratory Lessons in General Science*. An elm shoot, April 10, April 20, and May 20.

in still others, the leaves and flowers appear at the same time. Just as the little buds are opening, it is interesting to look at the tiny leaves and see how they are folded up in the buds during their long sleep. There is a definite order in which the buds of different trees open ; some are among the first to open and others last.

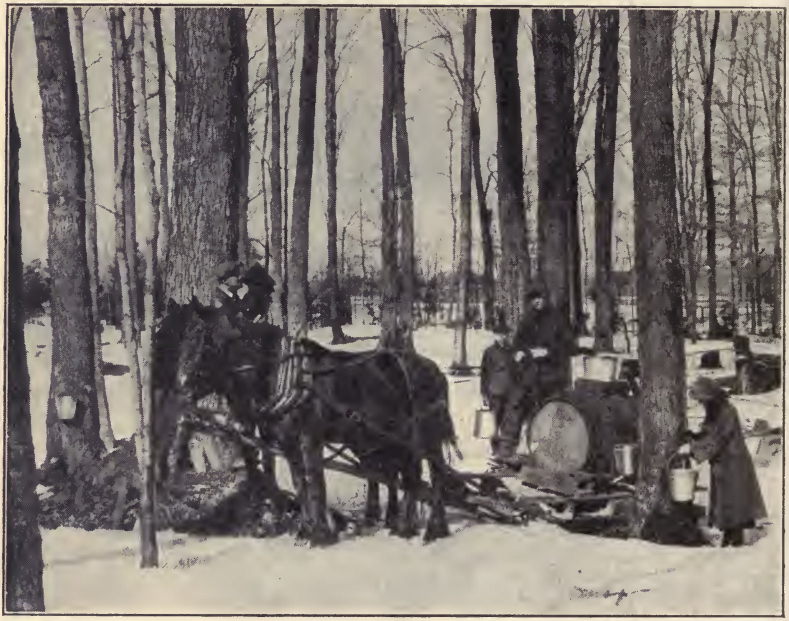


Photo by Ewing Galloway, N. Y.

Fig. 189. Gathering maple sap.

Opening buds do a great deal to make the spring landscape more beautiful. They present a wonderful display of a great variety of shades of green : light green and dark green, bluish green and yellowish green, brownish green and reddish green. Observe carefully this spring and see how many shades of green you can distinguish.

How is maple sugar made? In the spring time a large amount of sap starts to flow through the trees. Some kinds of maple trees have a sap from which maple sugar is made. In order to get this sap, small holes are bored in the trees, and into the holes are driven small spouts, from which the sap flows out into pails placed beneath. (Fig. 189) Although the sap comes out slowly, in the course of the day a large amount collects in the pails. This sap is a very weak solution of sugar and must be boiled down to make maple sirup. As the water boils away, the liquid gets thicker and thicker, until at last it is thick enough to be taken out and sold as maple sirup. If sugar is to be made, the sirup is boiled down still more.

Project 160 (G). Learning in what part of the stem maple sap passes up the tree.

1. Get a twig of the sugar maple. **2.** Put the cut end of the twig in a little red ink and allow it to stand for several minutes. **3.** With a sharp jackknife, cut sections across the stem. In what part did the red ink pass up? The sap passes up in the same part.

Project 161 (I). Making a willow whistle.

1. Get a smooth piece of willow twig about as big as your finger. **2.** Whittle off one end so that it slopes like a whistle. Cut a notch near the end. (Fig. 190 *a*) About four inches down cut around the bark all the way through to the wood beneath. Then pound the bark (not hard enough to scar or split it) with the handle of your knife until it can be turned around the wood and slipped off. (Fig. 190 *b*) **3.** Whittle out the wood as shown in Figure 190 *c*. Slip the covering back again, and the whistle is finished. **4.** Try making a whistle out of other kinds of trees, such as basswood and poplar. **5.** Make whistles of different lengths and diameters and note the effect on the pitch. Try cutting the first hole at different distances from the end. Try making whistles in different months.

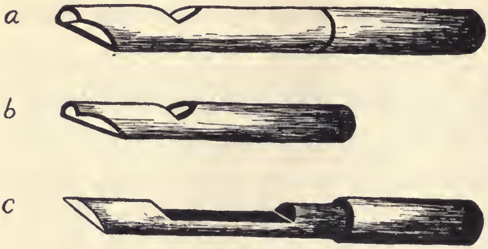


Fig. 190. Willow whistle.

Project 162 (G). **Watching the buds of trees open indoors.**

1. Find all the different kinds of shade trees growing in your locality that you can. Cut off a few twigs and bring them indoors. Put the cut ends in a dish of water. **2.** Change the water every week, and at the same time cut off about a quarter of an inch from the lower end of each twig. **3.** Watch the buds carefully as they unfold. Do all the buds open at the same time? Are the leaf buds and flower buds separate? Which appear first, the leaves or the flowers? How long does it take the buds to open after bringing them in? What happens to the bud scales? **4.** Make a series of drawings in your notebook, showing the changes in the buds as they open. (Fig. 188)

Project 163 (G). **Keeping a calendar of the times when the leaf buds of trees open.**

1. Get a large piece of heavy paper. Across the top put some decorations suggestive of leaves. Copy the following headings:

LEAF CALENDAR OF TREES

Name of tree	Date first leaf seen	Location of tree	Name of child first reporting

2. As soon as you find any trees with the leaves appearing, report to the teacher. Do not report until the buds have opened enough to show some of the leaves plainly spread out flat.

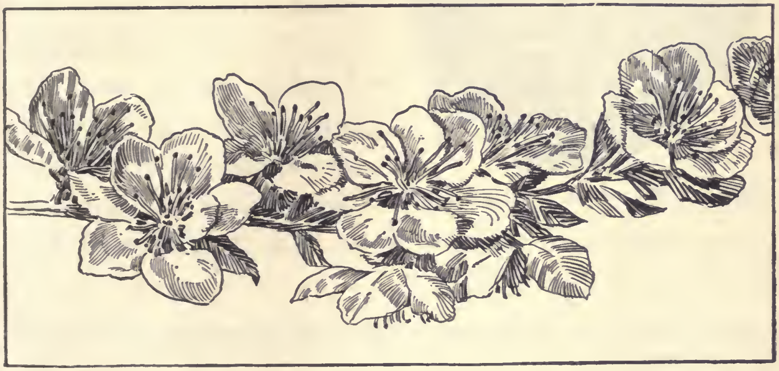


Fig. 191. Flowers of apple tree.

What kinds of flowers do trees have? The flowers of some trees are very showy and attractive, such as those of the apple (Fig. 191), peach, cherry, plum, magnolia, catalpa, tulip, and horse chestnut. The pussies of the willow are its flowers. However, the flowers of many of our common trees are so inconspicuous and unlike ordinary flowers that people do not realize that they are flowers at all. (Fig. 192) Some of these flowers are about the same color as the leaves, sometimes opening at the same time, and so they are not distinguished from the leaves. But they are real flowers and serve the chief purpose of the showier flowers, that is, to form seeds. The reason these flowers are not conspicuous is because they depend on wind instead of insects for pollination. Bright colors are one means by which insects are attracted to flowers. When the wind blows the pollen from the anthers on to the stigmas, the help of insects is not needed.

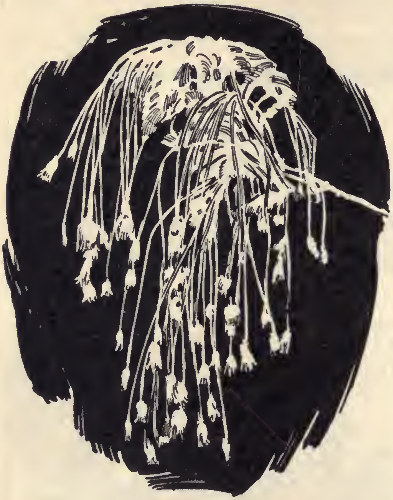


Fig. 192. Flowers of the sugar maple.

Project 164 (G). Keeping a calendar of the opening of the flower buds of trees.

1. Get a large piece of heavy paper. Across the top work out some decoration suggestive of flowers. Copy the following headings:

FLOWER CALENDAR OF TREES

Name of tree	Date first flower seen	Location of tree	Name of first child reporting

2. Whenever you see a tree with a bud so fully open that the flowers show plainly, report the tree to the teacher and have the columns filled out.

Project 165 (G). Comparing the blossoms of fruit trees.

1. Collect blossoms of different kinds of fruit trees, both wild and cultivated, such as apple, pear, peach, cherry, and plum. Bring them to school and put them in a vase filled with water. **2.** How many different kinds of trees can you find in blossom at the same time? Which one blossoms first? Which last? Copy the following table in your science notebook and fill out the points called for after you have observed the different fruit trees.

CALENDAR OF FRUIT TREES

Name of tree	Date of first blossom	Date of last blossom

3. Compare the different kinds of blossoms as regards both differences and similarities: *a.* In the number and size of petals. *b.* In the number of stamens. *c.* In the number of pistils. **4.** What sort of odor do the blossoms have?

5. By means of a paper bag cover a cluster of flower buds on a tree just before they open. Tie the bag on. Allow it to remain for several weeks after the petals of the other flowers have fallen. Then uncover. What difference do you notice between this cluster and other clusters? Can you explain the difference?

6. What color are the buds of the apple blossoms when they first begin to show?

CHAPTER XXI

WATER SPORTS

A. Swimming

There are several reasons why swimming is a good sport to learn: First of all, it is fun; second, it benefits the body through the exercise it gives and through the effect of the water on the skin; and third, it may be the means of saving a life — either your own or that of someone else.

Every swimmer should be cautioned not to go into the water right after eating. Wait at least an hour and a half after meals. Disregard of this rule may make one ill.

How should one breathe while swimming? In learning to swim it is quite as important to learn how to breathe as how to take the strokes with the arms and legs. Special attention should be paid to the two following suggestions:

1. Inhale *quickly* through the *mouth*. (Fig. 193)
2. Exhale *slowly* through the *nose*.

It is better to inhale through the mouth because the linings of the mouth are less sensitive to the water than are those of the nose. Also the lungs can be filled more quickly; and thus there is less chance for water being taken in at the same time. Some swimmers keep their heads under water except for a short time during which they turn their head to one side while they inhale (Fig. 193), the exhaling being done through the nose under water. By this method a person can swim faster and breathe more easily when the wind makes choppy waves that might interfere with the ordinary method of inhaling slowly through the nostrils.

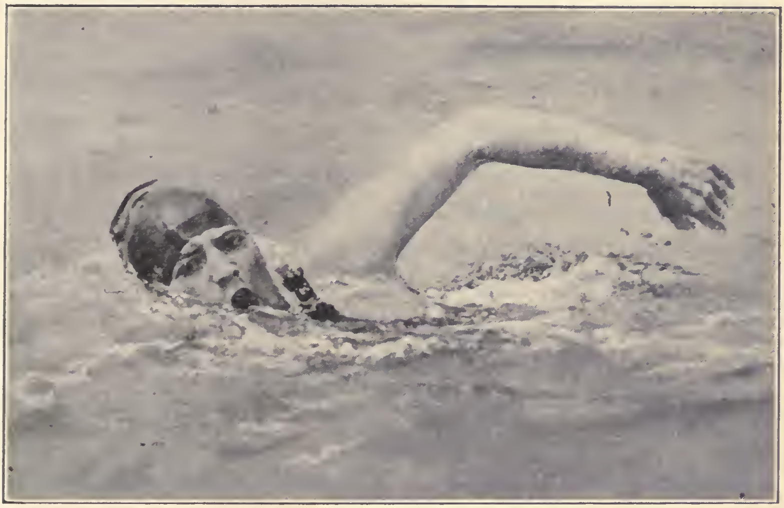


Fig. 193. Gertrude Ederle showing method of inhaling quickly through the mouth.

A third suggestion for proper breathing is that the breathing movements should keep time with the swimming movements of the arms and legs. A person should inhale when a certain motion of the arms occurs and exhale when another certain motion of the arms occurs.

It is a good idea to practice breathing alone, before you try swimming. Stand in the water up to your chin in such a position that you can take hold of some support. Take in a breath of air quickly through your mouth and duck your head under water. Then begin to breathe out slowly through your nose with your head still under water. By practicing this exercise frequently, it will become easier to you.

In learning the movements for swimming, it is often advisable to practice first on land until the strokes become natural. Each movement may be learned separately; first, breathing; second, arm movements; third, leg movements. Finally they may be tried all together. This land drill may be taken in two ways. You can stand up and do the motion with the arm and leg on each side in turn, or you can lie down on your stomach on a camp chair or stool and practice the movements with both legs and arms at the same time.

While practicing in water it is sometimes a help to use water wings, putting less and less air in them each time that you try, until finally you can swim alone. Sometimes it is easier to learn if a friend holds you up, placing his hand under your body. Always remember that the purpose of your swimming movements is twofold: first, to keep you afloat; and second, to propel you forward.

Some of the different kinds of strokes. It adds to the interest of swimming if one learns different kinds of strokes. Among the more common are the breast, side, crawl, and back strokes. Sometimes the boys call the breast stroke the *frog kick*. In this stroke the person lies on his stomach with his face straight ahead in the direction in which he is moving. At the end of each stroke after the last kick of the feet there is a little rest before starting the stroke again. During this time the body glides ahead as a result of the quick leg kick. This rest also helps to prevent the swimmer from getting tired. One common mistake made by beginners is that they make the motions too rapidly. The strokes should be taken slowly and deliberately. One objection to the ordinary breast stroke is the fact that, in order to breathe, the whole head and a part of the shoulders must be kept out of water; it is a general law of swimming that the more of the body that is out of water the harder it is to keep afloat.

Side Stroke. The side stroke gives more speed than the breast stroke and is also more difficult to learn. As the name suggests, the body is turned on the side; and the arms sweep down in front of the body. The movement of the legs is very different from the frog kick used in the breast stroke. The legs move back and forth as in walking, being bent from the knee. They are first separated, then brought together with a snap. This movement of the legs is sometimes called the scissors stroke.

Crawl stroke. (Fig. 194) This is the speediest of all the strokes. The person lies flat on the chest. The legs kick alternately up and down, bending from the hip as they rapidly thrash the water. The arms are alternately thrust ahead, being lifted out of the water and then pushed straight down under the body. The face is kept partly submerged, the head being turned regularly, just long enough to inhale.

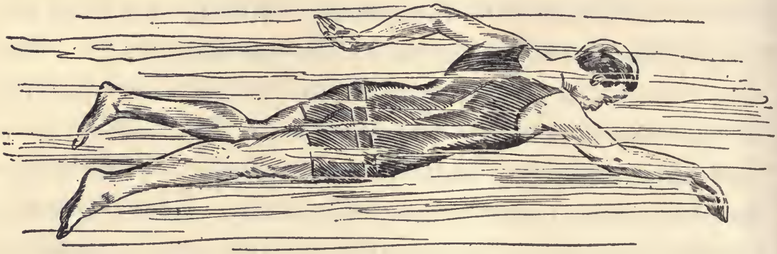


Fig. 194. The crawl stroke.

Back stroke. In some ways this is the easiest of all the strokes to learn and use. It is restful. After one gets tired from using the other strokes, he can turn on his back for a rest. One reason why this is an easy stroke is the fact that all the head, excepting the mouth and nostrils, are kept under water. The position is natural and restful; as we have noted in a previous paragraph, the more of the body that is submerged, the easier it is to keep afloat. There are a number of ways of doing the back stroke. One method is much like an inverted breast stroke, while another is like an inverted crawl. The back stroke is much used in life-saving.

Floating. Floating is a pleasant pastime that also furnishes a means of rest when a person becomes tired from swimming. Whether an object will float depends on whether it is heavier or lighter than the same volume of water. The weight of the human body is about the same as that of water of the same volume; since for most people it is slightly less, they can readily learn to float. Some people float more easily than others; for example, stout people float more easily than slender people. One of the things a person must overcome before he can make much progress in swimming is fear of water. Knowledge of the fact that most people are lighter than water, and hence can learn to float, will help remove this fear.

Floating is partly a matter of balancing the body around the buoyant center, the lungs. Usually the feet tend to sink and the body tends to take an upright position. This tendency may be overcome by pulling up the knees slightly, allowing the legs from the knees to hang straight down, and at the same time extending the arms to their full length above the head. (Fig. 195) Floating is made easier if the lungs are kept partially filled with air all the time. For this reason short breaths should be taken. It is easier to keep afloat in salt water than in fresh water, because salt water is

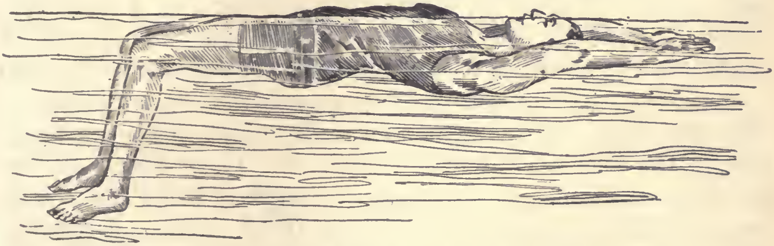


Fig. 195. Position of legs and arms while floating.

the heavier and hence has more buoyant force. The following experiment illustrates this difference between salt and fresh water:

Project 166 (G). Showing whether it is easier to float in salt water or in fresh water.

1. Procure two pint canning jars, one quart jar, a fresh egg, and some salt. **2.** Fill the two pint jars each about three fourths full of water. Into one stir enough salt (about five heaping teaspoonfuls) to make a strong solution. Put the egg in the salt solution; it floats. Put it in the bottle filled with water; it sinks. **3.** Carefully place the egg in the quart jar. Pour some of the contents of each of the two pint jars into this quart jar, first from one, then from the other, till the egg rests midway between the surface and bottom. Then by adding pure water the egg may be made to sink, and by adding salt water it may be made to rise. **4.** The explanation of the experiment is as follows: Objects float more easily in salt water than in fresh water because salt water is heavier than fresh water. In this experiment the egg is heavier than the fresh water and so sinks in it, while it is lighter than the salt water and so floats in it. It rests suspended midway when it is the same weight as an equal volume of the solution. One way of testing eggs is to see whether they sink or float in water. If an egg floats in fresh water, it is not a fresh egg. **5.** If you want to mystify some of your friends or the people at home with this experiment, prepare the salt solution in one of the jars beforehand without letting them know what you have done. Then after their curiosity has been aroused by the experiment, you can give the explanation.

How may drowning persons be saved? After you have learned to swim well yourself, it is well to learn a little about the methods of saving persons from drowning. In swimming to the aid of a drowning person, the rescuer should always approach from behind or else under water to prevent himself from being grabbed. The best way to save a person is to turn him on his back.

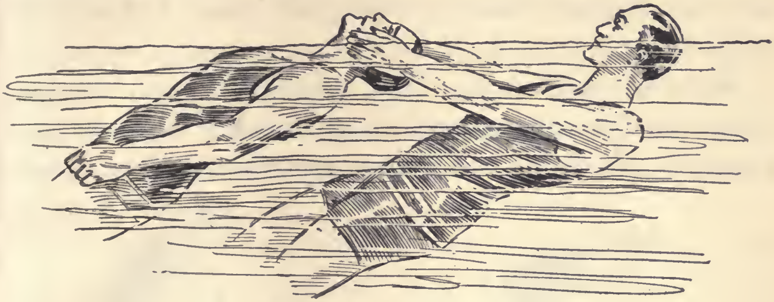


Fig. 196. Head carry.

There are several ways of carrying a helpless person. In one method, known as the *head* carry, each lies on his back. The rescuer places his hands on each side of the patient's head and then swims on his back. (Fig. 196) In another method, known as the *tired-swimmer*

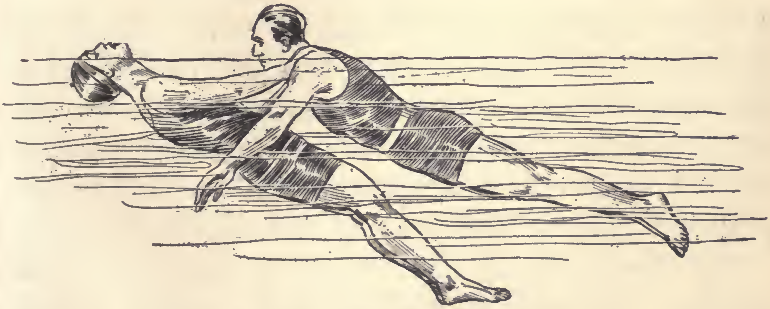
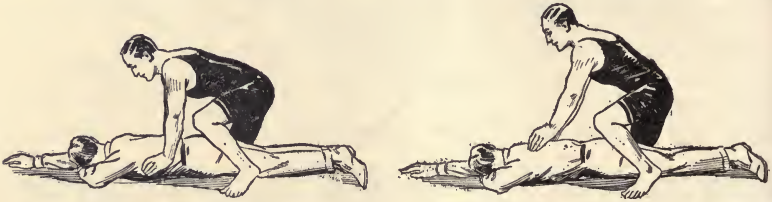


Fig. 197. Tired-swimmer carry.

carry, the rescuer swims on his breast, while the tired swimmer lies on his back. The tired swimmer places his hands on the shoulders of the rescuer, who then uses the breast stroke, pushing his friend before him. (Fig. 197)

After the person has been taken to shore, the next step is to bring about natural breathing. While several methods are used, the one considered the best is the *Schaefer* method. The patient is first stripped of clothing to the waist so that there will be nothing to interfere with breathing. He is placed face downward on the ground. One arm is stretched ahead; the other arm is bent and the head rested on the forearm, in such a position that the tongue will not fall back in the throat.



a. **Causing the patient to exhale by heavy pressure on the short or loose ribs. "Out goes the water."**

b. **The patient inhales when the pressure is withdrawn allowing the ribs to expand naturally. "In comes the air."**

Fig. 198. Schaefer method of artificial respiration.

The rescuer kneels with a knee on each side of the patient. He places his hands a short distance on each side of the spinal column with the fingers extended just below the lower ribs. He then leans forward exerting a downward pressure, thus forcing the impure air out of the lungs; then the pressure is released suddenly, allowing the lungs a chance to expand and draw in fresh air. (Fig. 198) This movement should be repeated as often as the person naturally breathes — that is, from twelve to fifteen times a minute. It may be necessary to continue this operation for as long as an hour or two, as people have frequently been saved after two hours' work. After natural breathing is restored, the limbs of the patient should be massaged and the body wrapped in warm blankets.

Of course a doctor should be sent for as soon as the patient is brought ashore. The above treatment is an emergency method to be used while waiting for the doctor.

B. BOATING

What cautions should be observed while using a boat? Boys and girls can have a great deal of fun boating and canoeing (Fig. 199); but parents are often afraid to let their children go out in boats for fear that they may be drowned. One reason why so many people are drowned while boating is because they never learned how to swim. For this reason the first thing to do in order that the danger from boating may be lessened is to learn how to swim. After that has been accomplished, there are four other boating rules that should never be broken:

1. Do not rock a boat, and do not go boating with a person who does.
2. Do not go out in an overloaded boat.

3. Do not stand up in a boat.
4. Do not go too far from shore in a large body of water, for squalls may come up quickly and prove dangerous.

Some of the kinds of boats. Some of the different types of small boats are the *dory*, the *skiff*, the *punt*, and the *canoe*. The dory has curved sides with boards lapping like those on the side of a house. Some dories have a pointed bow and a kind of square stern; others have both ends pointed and can be rowed in either direction. The skiff is a light boat with sloping sides and a light bottom. It may have the bow alone or both ends pointed. The punt is one of the safest and most useful boats. It is blunt at both ends and has a flat

Fig. 199. Canoeing.

bottom. The canoe is a very light kind of boat. It is easy to carry from place to place, and it can be paddled with great speed. However, great care should be taken in using canoes since they upset easily. The nearer the bottom of the canoe the weight is, the less danger there is of tipping over. For example, there is less danger when one sits or kneels on the bottom of the canoe than when he sits on the gunwale. In getting into a canoe, or any kind of boat, one should step into the center of the boat; and one should be seated at once and remain sitting in the middle of the seat.

How should a boat be rowed? While rowing, a person should sit in the after part of the boat so as to throw the bow up higher than the stern. Ordinarily the rower faces the stern, but sometimes he may face the bow and use the push stroke. Rowing is begun with the arms extended well forward and the oars thrown back with the blade straight up and down and just submerged under water. The stroke should be long and slow with a slight pause at the end. The blades should be kept at the same depth throughout the stroke. At the end of the stroke the blades are raised just free of water and turned so that their flat side is just toward the water while being carried back for the next stroke. One can soon learn to steer while rowing. He can sight some object over the stern of the boat and row so as to keep this in line. For a change, he may occasionally use the alternate stroke, taking a short stroke, first with one oar, then with the other. There are times when the rower will do better by facing the bow and using the push stroke, as when rowing through a narrow or dangerous passage. If one wishes to turn the boat quickly, he can pull with one oar and back water with the other.

Why does a boat float? The wood of which boats are made floats because it is lighter than water. But how do boats float when there are heavy loads in them? Perhaps, sometime, when you have been in wading or swimming you have tried to lift a stone under water and found that it is much easier to lift it then than when it is out of the water. Water has a lifting effect on things submerged in it. This effect is called the *buoyant force* of water and is always the same on all bodies of the same size.

The principle is stated as follows: An object in water is lifted up by a force equal to the weight of the water displaced; that is, *water displaced* means an amount of water of the same size as the object. For example, suppose a stone weighs twelve pounds and that a body of water of the same size as the stone weighs four pounds, then the buoyant effect of the water is four pounds, and the stone under water weighs eight pounds (12−4).

If a body is heavier than water, then this buoyant force is less than the weight of the body, and it sinks. If a body is lighter than water, then this buoyant force is greater than the weight of the body, and it floats. A boat sinks in water until the water displaced equals the weight of the boat.

We shall illustrate this principle by the following example: Suppose the water around a boat should freeze and the boat be taken out. There would be a hole in the ice the shape of the bottom of the boat. If this hole were filled with water and this water weighed, it would be found that the weight of this water just equals the weight of the boat.

Although steel is much heavier than water, a steel boat floats because it incloses a large amount of air; and the weight of the inclosed air and steel together is less than an equal amount of water.

Project 167 (G). Performing an experiment to show why boats float.

1. For these experiments you will need to procure the following materials: a spring balance, a small stone, a plate, a very small pail with a bail, and a piece of wood small enough so that it will float in the pail. **2.** Tie a piece of thread to a small stone and weigh it. Immerse the stone in water and weigh it again. Subtract this weight from its weight in air. How much weight has the stone lost? In order to find the specific gravity of the stone (that is, the number of times heavier than water it is) divide the weight of the stone in air by its loss of weight in water. Try other heavy substances, such as iron and lead.

3. Set the pail in the plate; fill the pail as full of water as you can without its running over; weigh the block of wood. Then carefully float it on the water in the pail. **4.** After the water stops running over into the plate, remove the block. Carefully lift up the pail, scraping the water from the bottom of the pail into the plate. **5.** Pour out the water from the pail and wipe it dry. Weigh the pail. Pour the water in the plate into the pail and weigh again. Subtract the weight of the pail to find out how much the water weighs. How does the weight of this displaced water compare with the weight of the wooden block?

Project 168 (G). Discovering why the end of an oar in water appears bent.

1. This is similar to a part of Project 100, but it may be performed again in this connection. Put a penny in the middle of the bottom of a tin cup. Stand so that you can just see the edge of the penny in line with the edge of the cup. **2.** Now add water to the cup. How does the position of the penny seem to change?

Explanation of experiment. By looking at Figure 128, page 195, you will probably understand the experiment. When light from the penny at *P* reaches the surface of the water at *G*, it is bent so that it travels along the line *AE* to the eye. The eye looking back along the line *EA* continues the line in a straight line to *H*, and it seems to the eye as though the penny were at the point *H*, instead of at *P*, where it really is.

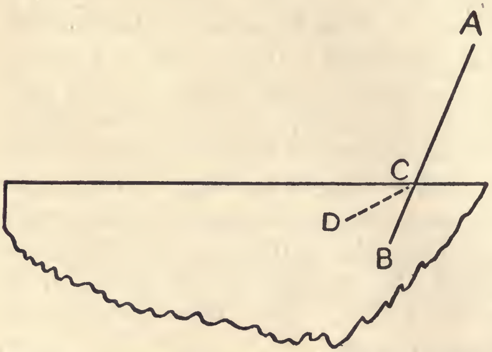


Fig. 200. Drawing to explain why an oar appears bent in water.

In Figure 200 the line *AB* represents an oar in water.

The part of the oar, *CB*, below the water seems to be in the position *CD*; hence the oar seems to be bent at *C*.

Project 169 (G). Making a simple steam turbine.

1. On many steamboats an engine called a steam turbine is used to turn the propellers that drive the boat. The following simple experiment illustrates the principle of the turbine:

2. Secure a glass flask or a bottle with a large mouth, a one-holed stopper to fit, and a piece of glass tubing about six inches long. (Fig. 201) **3.** Hold the glass tubing in the flame of an alcohol lamp or of a Bunsen burner till it softens. Then pull it out to a fine point. Break it off at the point, leaving a small hole. **4.** Insert this tubing through the hole in the stopper, placing the point uppermost.

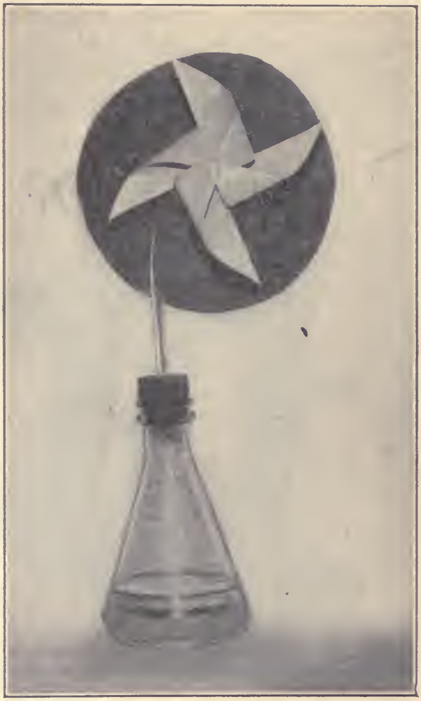


Fig. 201. Experiment to illustrate steam turbine.

5. Put about an inch of water in the flask and heat till it boils. If a bottle is used, it should be heated gradually to prevent breaking. **6.** Make a paper windmill as explained in Project 122. **7.** When the steam comes out of the tube, hold the windmill in such a position that the steam causes it to rotate.

C. WATER WHEELS

Project 170 (I) Making a water wheel. (Fig. 202)

1. Procure two pieces of wood about six inches long and from three quarters of an inch to an inch square. **2.** Find the middle point of each stick. On each side of this point at a distance equal to one half the thickness of the stick draw a line across it. Turn the stick over and do the same on the other side. Do this for both sticks. **3.** Starting from these lines, whittle the ends down on both sides till a thin blade is left. Prepare both sticks in the same way. **4.** Saw out a piece from the side of each stick, near the center, wide enough and deep enough so that the two pieces fit together. (Fig. 202) Fasten them with small nails. **5.** Bore a hole about a quarter of an inch in diameter through the center

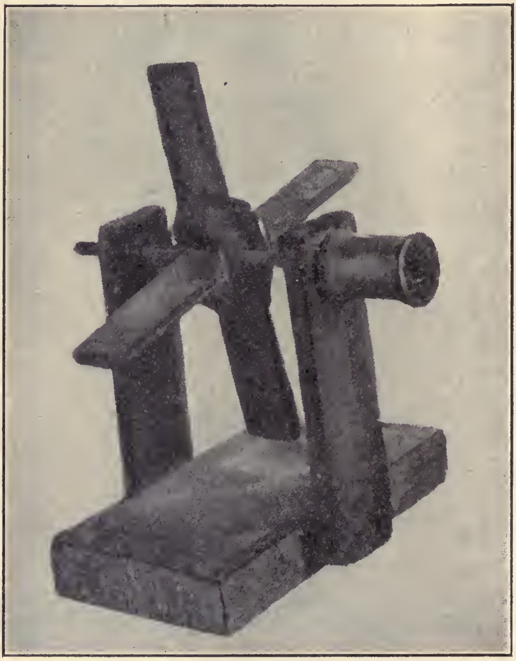


Fig. 202. Toy water wheel.

of the water wheel. Procure a round piece of wood about six inches long and whittle it down till it will fit this hole tightly. Push it halfway through. Drive in a small nail so that the wheel will not slip on its axle.

6. The next step is to make a support for the wheel. Get a piece of board about six by two inches, and two pieces of lath about six inches long. Bore holes in one end of each lath large enough to receive the axle of the wheel. Nail these cleats to the side of the board at the center point in such a way that they support the wheel with its axle passed through the holes. (Fig. 202) A spool may be fastened to one end of the axle so that a belt can be passed around it. **7.** In order to make the wheel run hold it under a faucet or place it in the bottom of a shallow stream of running water and put stones on the base to keep it in place.

APPENDIX

A. LIST OF PROJECTS

PART ONE. AUTUMN STUDIES

Chapter I. Garden Studies

A. GARDEN FLOWERS

Project 1, p. 4. Determining how hardy annual flowers are affected by the early autumn frosts. (I) [1]

Project 2, p. 5. Determining how tender annuals are affected by the early autumn frosts. (I)

Project 3, p. 5. Finding the easiest way of telling the phlox and the zinnia apart. (G)

Project 4, p. 6. Learning the names and appearances of the perennial flowers that bloom in the autumn. (I)

Project 5, p. 6. Reviewing the names of the autumn garden flowers. (G)

B. VINES

Project 6, p. 10. Learning the names and appearances of many different kinds of vines. (I)

Project 7, p. 10. Making a collection of vines for the school museum. (G)

Project 8, p. 11. Arranging vines according to their methods of holding on. (G)

C. BULBS

Project 9, p. 13. Planting bulbs in the home yard or school grounds so as to get flowers in the spring. (I and G)

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[1] *I*, in parenthesis, signifies that the project is preferably for the *individual; G*, in parenthesis, for the *group*.

Project 10, p. 16. Planting bulbs indoors either at home or at school in order to have flowers indoors next winter. (I and G)

Project 11, p. 16. Raising flowers from Chinese lily bulbs to be given as a Christmas present to a friend. (I)

D. HOUSE PLANTS FROM CUTTINGS

Project 12, p. 19. Raising plants from cuttings to furnish both the home and the school with house plants. (G)

CHAPTER II. WILD PLANTS

A. WILD FLOWERS

Project 13, p. 20. Learning the names and characteristics of the common wild flowers one sees in the autumn. (I)

Project 14, p. 21. Observing the differences by which two flowers may be told apart. (G)

Project 15, p. 21. Playing games with flowers. (G)

Project 16, p. 22. Observing the differences in similar kinds of flowers. (G)

B. MUSHROOMS

Project 17, p. 25. Making a collection of mushrooms. (G)

Project 18, p. 26. Making a collection of spore prints of mushrooms. (G)

C. FERNS

Project 19, p. 27. Making a collection of ferns. (G)

D. WEEDS

Project 20, p. 30. Learning how to tell rough pigweed from lamb's-quarters. (G)

Project 21, p. 30. Learning to name some of the common weeds. (I)

Project 22, p. 30. Learning how poison ivy and woodbine can be told apart. (G)

Project 23, p. 31. Making a collection of weed seeds found growing in the garden, in vacant lots, or by the roadside. (G)

Project 24, p. 31. Estimating the number of seeds borne by a single plant. (G)

E. TREES

Project 25, p. 37. Telling the oak and butternut trees apart by means of their leaves. (G)
Project 26, p. 37. Studying the maple family of trees. (G)
Project 27, p. 38. Studying the shade trees of your city. (G)
Project 28, p. 39. Making a calendar of the coloring of leaves. (G)
Project 29, p. 39. Making a collection of all kinds of tree leaves. (G)
Project 30, p. 40. Playing games with leaves. (G)
Project 31, p. 41. Making a collection of prints of leaves. (G)
Project 32, p. 42. Making a calendar of the falling leaves. (G)
Project 33, p. 42. Making a collection of tree seeds for the school museum. (G)

F. SEED TRAVELERS

Project 34, p. 45. Making a school collection of seeds to show how they are scattered. (G)

CHAPTER III. SOME INTERESTING INSECTS

A. INSECT ACTIVITIES

Project 35, p. 49. Making an insect net. (G)
Project 36, p. 50. Making an insect cage. (G)
Project 37, p. 50. Observing how insects grow up. (G)
Project 38, p. 52. Observing how grasshoppers and butterflies eat. (G)
Project 39, p. 53. Observing how the grasshopper breathes. (G)
Project 40, p. 54. Observing how insects move. (G)
Project 41, p. 57. Studying the song of the snowy tree cricket. (I)
Project 42, p. 57. Observing how crickets and grasshoppers make their sounds. (G)

B. GALLS

Project 43, p. 60. Making a collection of insect galls for the school museum. (G)

C. SOCIAL INSECTS

Project 44, p. 65. Observing how the nests of the paper wasps and that of the mud dauber differ from each other. (G)

Project 45, p. 68. Studying the habits of ants outdoors. (I)

D. GARDEN INSECTS

Project 46, p. 71. Studying the habits of some garden insects. (G)

E. HOUSEHOLD INSECTS

Project 47, p. 74. Observing the habits of mosquito wigglers. (G)

Chapter IV. Other Interesting Creatures

A. SPIDER WEBS

Project 48, p. 78. Studying the orb weaver's web. (I and G)

B. THE EARTHWORM

Project 49, p. 79. Making a cage in which an earthworm may be kept indoors. (G)

C. BIRD NESTS

Project 50, p. 81. Making a collection of nests for the school museum. (G)

Project 51, p. 83. Observing the kinds of materials of which birds' nests are made. (G)

Project 52, p. 83. Making a nest census of your city. (G)

Chapter V. The School Aquarium

A. FISHES

Project 53, p. 89. Observing the habits of the fishes kept in the aquarium. (G)

B. TADPOLES

Project 54, p. 91. Noticing the difference between the habits of the snail and the tadpole. (G)

C. WATER INSECTS

Project 55, p. 95. Watching the habits of those water insects that may be kept in an aquarium. (G)

Chapter VI. Rocks and Minerals

A. ROCKS

Project 56, p. 98. Showing the sorting power of water. (G)
Project 57, p. 100. Making a collection of rocks. (G)

B. MINERALS

Project 58, p. 101. Studying the formation of crystals. (G)
Project 59, p. 104. Making a collection of minerals. (G)

Chapter VII. Playground Sports

A. THE SEESAW

Project 60, p. 107. Discovering where two children must sit on a seesaw in order to balance one child on one end. (G)

B. THE SWING

Project 61, p. 110. Learning which will swing more times in a minute, a heavy child or a light child. (G)
Project 62, p. 111. Learning which makes more swings in a minute, a child who is swinging through a short distance or one who is swinging through a long distance. (G)
Project 63, p. 111. Learning which makes more swings in a minute, a child in a long swing or one in a short swing. (G)

Chapter VIII. Stars and Constellations

Project 64, p. 116. Learning to name the constellations that can be seen on any clear evening of the year. (I)
Project 65, p. 119. Naming the autumn constellations. (I)

PART TWO. WINTER STUDIES

Chapter IX. Winter Birds

Project 66, p. 130. Making a feeding shelf for the birds. (I)

Project 67, p. 131. Making a suet basket. (I)

Project 68, p. 132. Making an automatic feeder for seeds. (I)

Project 69, p. 133. Observing the habits of the birds that come to the lunch counter. (I)

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Project 70, p. 136. Learning how many kinds of evergreens grow in your neighborhood. (G)

B. DECIDUOUS TREES

Project 71, p. 142. Naming trees in winter from their study outdoors. (I)

Project 72, p. 143. Naming deciduous trees from an indoor study of twigs and fruits. (G)

Project 73, p. 143. Learning the age of twigs and trees. (G)

Chapter XI. Outdoor Winter Sports

A. COASTING

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Project 75, p. 148. Performing an experiment to find out whether a sled with two children on it goes faster or slower than a sled with only one child on it. (G)

B. SKATING

Project 76, p. 151. Finding out how much of floating ice is below water. (G)

Project 77, p. 154. Learning to do the figure eight. (I)

Project 78, p. 154. Learning to do the figure three, or the heart. (I)

Project 79, p. 156. Learning to do the serpentine. (I)

Project 80, p. 156. Improving your skating form. (I)

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B. THE MOTOR

Project 82, p. 161. Learning how the motor works. (G)

C. THE COMPASS

Project 83, p. 162. Studying the action of a compass. (G)

D. THE KALEIDOSCOPE

Project 84, p. 163. Noticing how many combinations of color and form you can see in the kaleidoscope. (G)

Project 85, p. 164. Noticing how many images of an object can be made by using two mirrors. (G)

E. THE COLOR TOP

Project 86, p. 166. Discovering what colors can be made with the color top. (G)

F. THE CAMERA

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Project 88, p. 170. Observing how a camera is made. (G)

G. THE AIRPLANE

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Project 90, p. 173. Observing how a toy airplane works. (G)

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Project 92, p. 178. Illustrating the motions of the earth by means of a top. (G)

I. TILLY TINKER, THE BALANCING QUEEN

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Project 94, p. 182. Performing experiments to illustrate the laws of balance. (G)

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Project 97, p. 185. Testing some common substances of the kitchen with litmus paper. (I)

C. FRICTIONAL ELECTRICITY

Project 98, p. 187. Performing some experiments with frictional electricity. (G)

D. THE WEIGHT OF THE AIR

Project 99, p. 191. Showing by experiments that air has weight. (G)

E. THE MAGIC PENNY

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F. EXPERIMENTS WITH ICE

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Project 102, p. 197. Making a tin cup freeze to a board. (G)

G. CAPILLARITY

Project 103, p. 198. Discovering how a blotter sucks up ink. (G)

H. EXPERIMENTS WITH THE EYE

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Project 105, p. 200. Showing the presence of the blind spot in the eye. (I)

Project 106, p. 201. Showing the value of having two eyes. (I)

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B. THE MOON

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C. THE STARS

Project 110, p. 220. Naming the brightest stars and constellations that may be seen in the winter time. (I)

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Project 115, p. 236. Learning whether you are giving your pet proper care. (I)

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B. WINDMILLS

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Project 128, p. 270. Making a plan of the vegetable garden. (I)
Project 129, p. 270. Making an early garden. (I)
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Project 131, p. 271. Discovering how the little squash seedling gets out of its tough seed coat. (G)
Project 132, p. 272. Making a pocket garden in which the growth of seedlings may be watched. (G)
Project 133, p. 273. Planting a late spring garden. (I)
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Project 145, p. 297. Learning to identify some common birds. (I)
Project 146, p. 299. Observing the habits of one kind of bird. (I)
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Chapter XIX. Flowers

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Project 157, p. 312. Reviewing the flowers you know by grouping them according to color and habitat. (G)
Project 158, p. 313. Observing how insects pollinate flowers. (G)
Project 159, p. 314. Observing the spring-blooming shrubs and garden flowers. (I or G)

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Project 160, p. 319. Learning in what part of the stem maple sap passes up the tree. (G)
Project 161, p. 319. Making a willow whistle. (I)
Project 162, p. 320. Watching the buds of trees open indoors. (G)
Project 163, p. 320. Keeping a calendar of the times when the leaf buds of trees open. (G)
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Project 165, p. 323. Comparing the blossoms of fruit trees. (G)

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Project 166, p. 330. Showing that it is easier to float in salt water than in fresh water. (G)

B. BOATING

Project 167, p. 337. Performing an experiment to show why boats float. (G)
Project 168, p. 338. Discovering why the end of an oar in water appears bent. (G)
Project 169, p. 339. Making a simple steam turbine. (G)

C. WATER WHEELS

Project 170, p. 340. Making a water wheel. (I)

B. TWO-YEAR COURSE FOR RURAL SCHOOLS

(To be used in alternate years)

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B. VINES			7–9	6,7,8.
C. BULBS	11–13	9.	13–16	10,11.
D. HOUSE PLANTS FROM CUTTINGS	17–19	12.		
CHAPTER 2 Wild Plants A. WILD FLOWERS				13,14,15,16.
B. MUSHROOMS	22–25	17,18.		
C. FERNS	26–27	19.		
D. WEEDS			27–29	20,21,22. 23,24.
E. TREES	32–37	25–33.		
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CHAPTER 3 Some Interesting Insects A. INSECT ACTIVITIES	46, 51–54,56,58	35–42.		
B. GALLS			59–60	43.
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E. HOUSEHOLD INSECTS			72–74	47.

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B. THE EARTHWORM	79	49.		
C. BIRD NESTS			80,81	50,51,52.
CHAPTER 5 The School Aquarium A. FISHES	84–89	53.		
B. TADPOLES	90	54.		
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B. MINERALS			102–104	58,59.
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CHAPTER 10 Trees in Winter A. EVERGREENS	134–136	70.		
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CHAPTER 21 Water Sports				
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B. BOATING			333–337	167,168,169.
C. WATER WHEELS				170.

C. BOOKS FOR SUPPLEMENTARY READING

ANIMALS

The Burgess Animal Book for Children, Thornton W. Burgess. Little, Brown, and Co., Boston.

Our Animal Friends and Foes, William A. DuPuy. John C. Winston Co., Philadelphia.

The Bears of Blue River, Charles Major. The Macmillan Co., New York City.

Jimmie, The Story of a Black Bear, Ernest Harold Baynes. The Macmillan Co., New York City.

The Christmas Reindeer, Thornton W. Burgess. The Macmillan Co., New York City.

Children of the Wild, Charles G. D. Roberts. The Macmillan Co., New York City.

ASTRONOMY

Astronomy for Young Folks, I. M. Lewis. Duffield and Co., New York City.

The Book of the Stars for Young People, William T. Olcott. G. T. Putnam's Sons, New York City.

Stories of Starland, Mary Proctor. Silver, Burdett and Co., Boston.

The Sky Movies, Gaylord Johnson. The Macmillan Co., New York City.

The Star People, Gaylord Johnson. The Macmillan Co., New York City.

BIRDS

The Burgess Bird Book for Children, Thornton W. Burgess. Houghton Mifflin Co., Boston.

First Book of Birds, Olive Thorne Miller. Houghton Mifflin Co., Boston.

Second Book of Birds, Olive Thorne Miller. Houghton Mifflin Co., Boston.

Our Bird Friends and Foes, William A. DuPuy. John C. Winston Co., Philadelphia.

FLOWERS

Burgess Flower Book for Children, Thornton W. Burgess. Little, Brown, and Co., Boston.

Wild Flower Book for Young People, Alice Lounsberry. F. A. Stokes Co., New York City.

GARDENING

The Garden Book for Young People, Alice Lounsberry. F. A. Stokes Co., New York City.

When Mother Lets Us Garden, Frances Duncan. Moffat, Yard and Co., New York City.

Little Gardens for Boys and Girls, M. Higgins. Houghton Mifflin Co., Boston.

Harper's Book for Young Gardeners, A. H. Verrill. Harper and Bros., New York City.

The Beginner's Garden Book, Allen French. The Macmillan Co., New York City.

INSECTS

Ways of the Six-Footed, A. B. Comstock. Ginn and Co., Boston.

Our Insect Friends and Foes, William A. DuPuy. John C. Winston Co., Philadelphia.

Hexapod Stories, Edith M. Patch. Atlantic Monthly Press, Boston.

Farm Spies. How Boys Investigated Field Crop Insects, A. F. Conradi and W. A. Thomas. The Macmillan Co., New York City.

MINERALS AND ROCKS

The Boy Mineral Collectors, Jay G. Kelley. J. B. Lippincott Co., Philadelphia.

OUTDOOR SPORTS

Winter Camping, Warwick S. Carpenter. The Macmillan Co., New York City.

Outdoor Sports, Claude H. Miller, in Library of Work and Play. Doubleday, Page and Co., New York City.

The Book of Winter Sports, J. C. DIER. Macmillan Co., New York City.

PETS

Pets for Pleasure and Profit, A. H. VERRILL. Chas. Scribner's Sons, New York City.

When Mother Lets Us Keep Pets, C. JOHNSON. Moffat, Yard and Co., New York City.

TOYS

Home Made Toys for Girls and Boys, A. NEELY HALL. Lothrop, Lee and Shepard, Boston.

Playing with Clay, IDA W. WHEELER. The Macmillan Co., New York City.

Your Work Shop, EDNA PLIMPTON. The Macmillan Co., New York City.

TREES

Trees Every Child Should Know, J. E. ROGERS. Doubleday, Page and Co., New York City.

WEATHER

Water Wonders Every Child Should Know, JEAN M. THOMPSON. Doubleday, Page and Co., New York City.

GENERAL

Harper's Book for Young Naturalists (Good for collecting), A. H. VERRILL. Harper and Bros., New York City.

Wonder Book of Knowledge (Good for its pictures). John C. Winston, Philadelphia.

The Spinner Family, ALICE J. PATTERSON. A. C. McClurg and Co., Chicago.

Trees, Stars, and Birds, E. L. MOSELEY. World Book Co., Yonkers-on-Hudson, N. Y.

Games for the Playground, Home, School, and Gymnasium, JESSIE H. BANCROFT. The Macmillan Co., New York City.

First Lessons in Nature Study, EDITH M. PATCH. The Macmillan Co., New York City.

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